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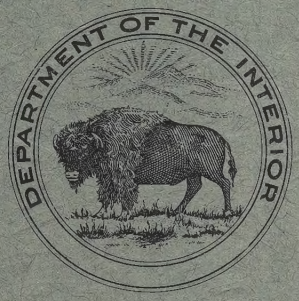

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The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

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SURVIVAL OF HATCHERY TROUT IN STREAMS AND POSSIBLE METHODS OF IMPROVING THE QUALITY OF HATCHERY TROUT

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IN RECENT YEARS the planting of trout in streams has been depended upon largely to maintain adequate fishing. The popularity of such management procedures has continued and increased, owing more to popular pressure than to clear-cut demonstration of effectiveness in producing better fishing. Plantings of trout in streams should be recognized as being made for one or the other of two distinct purposes: (1) "stocking for the rod" by plantings of fish of a size and at a time of year to allow for immediate catch, i.e., legal-sized fish during or just prior to the angling season; (2) plantings of fish of a size or at a time of year to necessitate a considerable passage of time before the fish will be available to anglers, i.e., legal-sized fish in the fall season or fingerlings at any season.

In plantings of the first type, little ability to survive is necessary and the catch may be increased to almost any desired amount by increasing the number of fish planted and the fishing pressure. Plantings of that type are being utilized in good trout streams and in what might be rated as class B streams. Class B streams are incapable, for one or more physical or chemical reasons, of maintaining much of a stock of trout the year round; in these little or no natural recruitment can be anticipated and few planted fingerlings can be expected to survive to legal size. Streams that are habitable for trout for only a couple of months in the spring are examples of this class.

Such plantings are relatively well established in principle. Research has shown that plantings immediately prior to or during the early part of the fishing season are superior to late season or fall plantings. There are also many data to indicate that the ultimate return to anglers in seasons following the one in which the plantings were made, is negligible; therefore, it would appear efficient to take steps to insure a maximum catch of planted legals during the current season. Spot planting in areas where the fishing pressure is greatest, and the choice of species, are two means of effecting this result. In regard to species, where equal numbers of legal-sized brook and brown trout were planted, the catch of brook trout was about twice that of the browns (Schuck 1942); thus it might prove more efficient to plant brook trout for a maximum of immediate fishing returns.

The balance of this paper will be restricted to a discussion of the second type of plantings: those in which survival is necessary over a considerable period of time before the fish are available to anglers.

As already pointed out, plantings of this type require streams in which it is possible for a stock of trout to maintain itself throughout the year. These trout streams (class A) are those in which natural reproduction and survival are possible, or those in which planted fry or fingerlings are able to survive in some number until they reach legal size.

Available data will be summarized in five parts, showing that--

(1) The catch of such plantings has been extremely low.

(2) This low catch has been due to a lack of survival rather than to ineffective angling removals.

(3) The survival of such hatchery fish is not only low, but apparently much lower than the survival of wild fish of comparable ages.

(4) It is possible that modern hatchery methods and techniques contribute to low survival ability of hatchery fish after they are planted.

(5) There is a distinct need to evaluate critically the possible effects of all hatchery procedures and to modify such procedures as are found detrimental to the survival ability of hatchery trout.

The methods of evaluating soundly alternative hatchery techniques could be developed through an experimental hatchery and stream program and by utilizing modern experimental designs as developed in agricultural research.

CATCH OF HATCHERY TROUT BY ANGLERS

Catch of Plantings of Fingerlings

Regarding results of fingerling plantings, Shetter (1939) reports catches of brook trout: 1.6 percent of 500 5.5-inch, 0.03 percent of 9,778 3.5-inch, 0.00 percent of 1,000 4-inch, 0.6 percent of 496 5.5-inch, 0.00 percent of 98 4.6-inch, 0.00 percent of 197 5.9-inch, 0.00 percent of 1,000 3.5-inch, 1.07 percent of 468 4.8-inch, 0.00 percent of 506 4-inch, and 0.02 percent of 5,000 3.9-inch fish.

Somewhat similar results have been found by other workers. Surber (1937) reports catches of rainbow trout: 6.0 percent of 1,080, 1.5 percent of 2,160, and 0.7 percent of 1,253 4-inch fish. He also reports (1940) returns of brook trout: 0.7 percent of 2,841 4-inch, 1.3 percent of 787 5-inch, and 8.7 percent of 1,106 5.6-inch fish; and returns of rainbow trout: 0.72 percent for 2,632 4-inch and 3.3 percent for 3,741 5-inch fish. Of 11,107 brook and rainbow trout planted, only 2.4 percent were caught.

Catch of Plantings of Legal Size

Regarding catches of legal-sized fish that were planted considerably before the opening of the fishing season (fall plantings), Nesbit and Kitson (1937) report that in Massachusetts returns numbered only 1.5 percent of 645, 2.3 percent of 554, and 3.1 percent of 589 brown and rainbow trout. Shetter and Hazzard (1941) report an average take of 3.4 percent of 4,298 fall-planted brown, rainbow, and brook trout. Smith (1941) reports a catch of only 1 percent of brook trout and concludes that low recoveries in the year after planting seem to be due to the natural inability of the trout to survive the winter. Gee (1942) reports a catch of 4.7 percent of two plantings of New Mexican native trout; Holloway and Chamberlain (1942) report catches of 3.16 percent of 57,029 fall-planted rainbows and 1.34 percent of 23,000 fall-planted brook trout.

It is apparent that anglers took negligible numbers of these hatchery plantings. It might be argued that although they contributed little to anglers' catches, these hatchery plantings survived in the stream and reproduced in considerable numbers; however, those creel censuses that have covered several consecutive seasons have not disclosed the presence of such survivors in any numbers, and the inescapable conclusion is that they did not survive to any appreciable extent.

The effectiveness of hatchery plantings is rather poorly demonstrated by the catch, inasmuch as the catch is influenced to a considerable extent by: (a) the amount of fishing pressure, and (b) the extent of the area stocked (density of

fish present).

The standard "fishing day" and "fisherman hour" have been used to supplement total catch, but possibly these indices are so influenced by factors such as weather, gear competition, seasonal differences, differential ability of anglers, and other conditions--the effects of which have not yet been demonstrated clearly--that comparison on the basis of them may be misleading.

Recently employed "population estimates" or inventories of the stock on hand at periodic intervals appear to offer a more useful tool for determining the effectiveness of hatchery plantings, by demonstrating the actual survivals over specified periods of time. Some of the available data on survival rates are reviewed in the following section.

SURVIVAL OF PLANTED HATCHERY TROUT

Considering the survival of plantings of fingerling hatchery trout, White (1930) conducted experiments in segregated sections of a stream on Prince Edward Island, Canada. From his seining operations he estimated that the survival of fingerling brook trout ranged from 15 to 46 percent over a period of only 3 months in the summer. In another series of experiments (1924), 5,000 fingerlings were planted in each of two streams: after 3 months, 1,526 (30.5 percent) were estimated to have survived in one, and only 181 (3.6 percent) in the other. White (1927) also reports survival of only 27.5 percent of 4,020 fingerlings 3 months after planting. Needham and Slater (1944) have reported on extensive experiments dealing with 63 plantings of brown and rainbow trout: an over-all survival of 63.7 percent was obtained for brown trout fingerlings, 46.6 percent for large rainbow fingerlings, and 44.2 percent for smaller rainbows. These results were obtained after plantings 3 to 5 months earlier in the summer.

Schuck and Kingsbury (in press) report that of several plantings of fingerling brown trout in Crystal Creek, New York, the highest survival was noted for a planting of 6,300 brown trout averaging 3.7 inches in September 1941. It was estimated that 6.3 percent of the fish survived until September 1942: this estimate was obtained by inventorying by the electrical-shock method 13 sample sections of the stream. Various short-term survival studies in this stream over summer periods produced survivals not exceeding 16 to 18 percent for 1- to 2-month periods

It appears that not only did hatchery fingerlings fail to influence materially the anglers' catch in most situations, but the survival of these fingerlings was low, obviously much lower than was "expected" (stocking tables of Embody 1927 and Davis 1938). Embody's table is based upon the expected survival to a legal size (6 inches) of 5 percent, 35 percent, 60 percent, 80 percent, and 100 percent, respectively, of the 1-, 2-, 3-, 4-, and 6-inch fish planted. Davis' expected survivals are: 5 percent, 20 percent, 50 percent, 70 percent, 80 percent, and 90 percent, respectively, of 1-, 2-, 3-, 4-, 5-, and 6-inch fish to a legal size of 7 inches. Much lower survivals than these were obtained in all the studies made.

For any critical evaluation of hatchery fish, however, it would appear necessary to compare their survival with that of wild fish. Unfortunately, comparable data on this subject are limited. The data needed are the relative survivals of wild and hatchery fish of the same age, in the same stream, and over the same span of time. Lacking this ideal, usable data would consist of a large number of estimates on the survival of wild fish in many streams and in various years, estimates which might be compared in general with the average of large numbers of estimates on the survivals of hatchery fish in many streams and in various years.

RELATIVE SURVIVAL OF WILD AND HATCHERY TROUT

Estimates of survival of wild fingerlings are available from various sources. Table 1 presents Shetter and Hazzard's (1939) recoveries of fingerlings and yearlings during a summer's seining of three streams. If it is assumed that in each of 2 years a similar number of fingerlings

TABLE 1.--Data from Shetter and Hazzard (1939)

Species	Age 0+	Age 1+
Brook trout	112	58
Brown trout	180	32
Rainbow trout	970	133

was produced, and that the sections of stream inventoried were representative, the theoretical percent survival of fingerling to yearling might be estimated at 52 percent for brook trout, 18 percent for brown trout, and 14 percent for rainbow trout.

Shetter and Leonard (1943) report a September population of 605 wild brook trout in 590.5 feet of Hunt Creek, Michigan. Age analysis showed that 46.7 percent of these 605 fish were young of the year, 30.8 percent were yearlings. Assuming the same recruitment of young to the two Septembers, an estimate of survival from 0+ (fingerling) to 1+ (yearling) age would be 65.9 percent.

By diversion and pumping, Needham, Moffett, and Slater (1945) estimated the numbers of wild brown trout in a section of Convict Creek, California. Table 2 lists the numbers of fingerlings and yearlings present in August of the years 1939, 1940, 1941, and 1942, according to these investigators. If it is assumed that 1,714 fingerlings in August 1939 resulted in 704 yearlings in August 1940, 4,905 fingerlings in 1940 resulted in 424 yearlings in 1941, and 3,241 fingerlings in 1941 resulted in 407 yearlings in 1942, then, of all 3 years' survivals, a total of 9,860 fingerlings produced 1,535 yearlings or a survival of 15.6 percent.

Some angling mortality as well as natural mortality is represented in these survivals, however, and from the published data there appears to be no way to segregate the effects of each.

These data on the average survivals of wild fingerlings (young of the year) to yearling age, may be compared roughly with the average survivals of planted hatchery fingerlings already noted. The general conclusion is that the survival of the hatchery fingerlings was considerably less than that of the wild fingerlings.

There are, unfortunately, very few data available on the relative survival of hatchery and wild fingerlings in the same stream and over the same span of time. There are some data available from research on Crystal Creek. It has been noted (Schuck and Kingsbury, in press) that for several plantings of hatchery brown trout fingerlings in various Septembers, the highest (also the most accurate) estimate of survivals was 6.3 percent to the following September (1942).

The survival of wild fingerling brown trout also was estimated in the electrical inventory that produced these data on survival of the hatchery fish. Numbers of wild fingerling brown trout (young of the year) and the numbers of wild yearling brown trout estimated to be in Crystal Creek, New York, in September of the years 1939-42, as reported by Schuck (1945), are shown in table 3. It may be seen that of the fingerlings present in 1939, 31.7 percent survived until a year later; and of the fingerlings in 1940 and 1941, 17.5 percent and 23.0 percent, respectively, survived until 1 year later.

TABLE 2.--Data from Needham, Moffett, and Slater (1945)

Age	Year 1939	1940	1941	1942	Total
0+	1,714	4,905	3,241	1,735	9,860
1+	-	704	424	407	1,535
Percent survival 0+ to 1+	-	41	9	12	15.6

In contrast with the survival of the planting of hatchery trout in September 1941 (survival of 6.3 percent to September 1942), 23.0 percent of the wild fingerling brown trout survived from September 1941 to September 1942. The difference between 6.3 and 23.0 percent is statistically significant.

POSSIBLE REASONS FOR LESSENED ABILITY OF HATCHERY TROUT TO SURVIVE

It has been indicated that the survival of hatchery-reared trout planted in streams, appears to be considerably below expectation, and low also when compared on the basis of limited available data on survival of naturally reared trout. The possibility that hatchery and wild trout are different in their ability to maintain themselves, thus seems obvious. Recognition of this possibility and the initiation of critical experiments to test it further, seem important. If this possibility is a fact, then to determine the cause of the lessened ability of hatchery trout to survive would seem to be a most profitable line of research.

The possible differential ability of the two types of trout to survive is mentioned by Gerrish (1935), who noted that very few hatchery trout more than 4 years old were found in English streams, but that naturally reared trout as old as 6 to 8 years were commonly found. He suggests that the rapid rate of growth in the hatchery may account for a short span of life when the trout are liberated in the natural environment and forced to forage for themselves. The works of McCay (1933) and Ratcliff (1943) have also indicated the possible effect of growth rate on length of life in brook trout and rats.

Hess (1935) has shown that fatty degeneration of the pancreas is present in hatchery trout. Carefully run experiments showed that this condition was induced by: (1) the addition of fat, or fat and carbohydrates, to the diet; (2) overeating; and (3) the lack of normal muscular activity. These conclusions were attained by rearing similar groups of trout under different conditions for a period of time and then examining the organs histologically. A brief review of this work is pertinent.

1. The addition of fat, or fat and carbohydrates, to the diet was produced by the addition of lard and cooked cornstarch to 100-percent beef liver or pig spleen. The abnormal condition of the pancreas was greater in trout that were fed diets which contained lard and cornstarch than in the trout fed pure meat.

2. The effect of overeating was produced by feeding some lots of trout three times a day and some lots eight times a day on the various diets, so that the heavily fed lots received approximately 2.7 times as much as the others. Those fed eight times a day had a more serious degeneration of the pancreas than those fed only three times.

3. The effect of varying amounts of muscular activity was produced by adjusting the rate of flow of water through the troughs to either 1 gallon per minute or 12 gallons per minute. Fish kept in the more slowly moving water had more degeneration of the pancreas than those in the faster water.

It is almost unnecessary to note that a common hatchery practice is to force feed in an effort to produce larger fish

TABLE 3.--Data from Schuck (1945)

Year	Fingerlings	Yearlings	Percent survival
1939	1,780	-	-
1940	1,780	563	31.7
1941	1,854	311	17.5
1942	-	431	23.0
1939-41 total	5,414	-	-
1940-42 total	-	1,305	24.1

in a shorter time, and that hatchery trout probably obtain much less exercise than fish in the wild.

Hewitt (1937) has pointed out that fatty degeneration of the liver is produced in trout raised in the usual hatchery manner, and in an annual report (1937) the New York State Conservation Department notes that "... in recent years evidence has been accumulating that in an attempt to achieve maximum growth in hatchery trout these fish are sometimes overfed, and that such overfeeding results in a fatty degeneration of the liver."

Thus, it appears that abnormal conditions may be brought about by hatchery methods. It is possible that the hatchery practices which produce these conditions of the internal organs are also among the factors that cause the survival of hatchery fish to be so low when they are planted in the wild.

Among the possible causes of the low survival ability of hatchery-reared trout, the following may be noted:

1. High percentages of fats and carbohydrates in diets.

2. Overfeeding, which leads to (among other things) detrimentally high growth rates.

3. Relative lack of exercise.

4. Artificial conditions where little or no foraging for food is necessary.

5. Relative freedom from predators.

6. Relative stability of water temperature the year round, a condition which does not exist in most trout streams. Hatchery trout, if reared in spring water, are usually subjected to neither the low temperature (approximately 32° F. during winter) nor the high temperature (above 75° F.) which trout in the wild often must endure. If trout have become accustomed to the rather stable temperatures of the hatchery, the more variable temperatures in the wild might contribute to their mortality.

7. Continued domestication of hatchery breeders.

8. Intentional or unintentional selection of brood fish for good performance in the hatchery, i.e., for rapid growth rate, large production of eggs, and like qualities. Such selection does not necessarily produce fish with the qualities to survive in the wild.

9. Relative absence of natural live food. In regard to the importance of live food for trout, Atkins, as early as 1908, noted that the substitution of the flesh of mammals for the natural food is followed by deterioration in some of the most important functions of the fish. Mellen in 1928 emphasized the value of live food. Embody and Gordon (1925) concluded that the proportions in which nutrients occur in the natural ration of wild trout would appear to be desirable, and that in this respect the artificial ration should approximate the natural ration as nearly as possible.

10. Transporting and planting methods. The whole question of transportation and planting methods appears to offer tremendous possibilities for increasing the effectiveness of hatchery operation. This end point of all hatchery endeavor has for years been carried out rather haphazardly in many localities. It can hardly be argued that the manner of transporting, handling, and planting does not affect survival rate, although admittedly there are few data on this seemingly important subject. If it could be determined what methods of transporting (circulating water vs. oxygen vs. compressed air), what maximum loads, water temperature, method of handling, etc., and what degree of tempering in getting fish from hatchery waters into waters of transporting medium (if they be different) and from transporting medium to waters of the streams, would give the greatest survival in the streams--if all these problems could be determined, much improved hatchery operation probably would result. The complexity of the problem is illustrated in part by Davis (1941): "Many of our hatcheries have a highly mineralized water supply and a sudden transfer of fish raised in them to soft water with a low mineral content, such as is found in the majority of our trout streams, necessitates fundamental physiological readjustments. The same is true, of course, of the gas content which may show great variations."

Haskell (1941) has carefully worked out maximum loads, most efficient temperatures, depths of water, etc., for transporting brown trout when using oxygen. It remains, though, to determine which

procedures, in addition to increasing the carrying capacity of tanks en route to planting sites, would also increase the survival rate of fish so transported.

EVALUATION OF EFFECT OF HATCHERY PRACTICES ON SURVIVAL OF TROUT PLANTED IN THE WILD

Necessity of Such Evaluation

Thus far, the data presented make it seem that the survival of hatchery-reared trout is considerably below what has been expected in the past and, furthermore, is considerably inferior to the survival of wild trout. Inevitably, the conclusion is that there is something wrong with hatchery trout--something that decreases their ability to survive in the wild. If this is true, then such inability is probably the result of some conditions in their artificial hatchery life.

Some of the hatchery conditions which may contribute to the "softening up" of hatchery fish to the extent that when liberated they are relatively unable to cope with the dangers and problems of stream survival, have been mentioned. It appears to be of extreme importance to evaluate as many as possible of these and other hatchery methods in an attempt to isolate those which are detrimental to the sustaining quality of fish reared under those methods, and--if such action can be shown to be worth the expense involved--to eradicate or modify such methods as are proved detrimental.

It should be repeated that the purpose of such an investigation would not be to improve the quality of those trout that are stocked only for immediate catch (type 1 plantings), but to improve the quality of those fish intended to survive over longer periods of time in better streams. The methods now in use to produce fast-growing and cheap fish appear to be adequate if it is not necessary that these fish survive very long in the streams.

It should also be emphasized that survival in streams only, and not in lakes or ponds, is considered in this paper. The ideas may apply, however, not only to trout but also to the species of salmon that spend a considerable period of time facing the rigors of stream life before going to sea, particularly, perhaps, Atlantic salmon.

Methods for Such Evaluation

Let us assume for the moment that a genuine attempt is to be made to evaluate the effect of various hatchery methods upon the quality of hatchery fish that are desired to survive over periods of time after planting in streams. A possible method of making this evaluation is outlined briefly in the following paragraphs:

1. The experimental hatchery system would have to be established. Here, groups of trout would be produced by the various methods that were deemed important enough to evaluate. Such experiments should be so designed that between groups of trout there would be no important differences except those due to the effect being evaluated. Randomization of samples and experimental designs, similar to the modern methods that have been used extensively in agricultural crop experiments (Fisher 1937) but which have been largely neglected in fishery research until the present, should be utilized.

2. An agreement would have to be reached in regard to the criteria to be utilized in judging the relative superiority of the various groups of trout. In the past, there has been a great deal of research to develop a "better" trout, i.e., one meeting specifications of rapid growth, good survival, favorable relation of length to weight, and other qualities, during its stay in the hatcheries. It would appear, however, that the criteria should be applied to the performance of the hatchery product in the streams and not merely in the hatcheries. Hatcheries are not an end in themselves: their purpose should not be to show increased output and decreased costs year by year but, rather, to help produce better fishing in the streams. The proper criteria then would appear to be relative growth and survival, and possibly other qualities, in stream areas after planting.

Thus, once the groups of fish had been reared under the hatchery conditions that it was desired to test, the groups would be marked for future identification and

planted at the same time in the experimental stream areas.

3. The general approach would be to allow the various groups of fish to be subjected to the environment for a period of time and then to evaluate the relative growth and survival of these groups. A method of counting and measuring the fish after the passage of this period of time is, therefore, necessary. Methods which have been used for collection of fish for examination are: poisoning, effecting temporary or permanent loss of equilibrium (Leonard 1939, Smith 1940, Embody 1940); seining (Trippensee 1937, Shetter and Hazzard 1939); diversion of the stream to another channel (Embody 1929); pumping sections dry (Needham and Rayner 1939); and more recently, electrical shocking (Haskell 1940; Haskell and Zilliox 1941; Hazzard, Leonard, and Shetter 1947; Schuck 1943, 1946).

Whatever method of population estimate is used, it obviously will be necessary to supplement such an estimate with a creel census if angling is permitted during the experiment. Otherwise, an unknown number of fish in the legal-sized group would be removed by angling during the fishing season and this would affect the survival determination.

In using most of these methods for collecting the fish in a section of stream, 100-percent collection of the fish in the section rarely is effected. Furthermore, the efficiency of the method (the percent collected) varies under different conditions. The efficiency of capture by the electrical-shocking method has varied greatly with the size of fish: the larger sizes are captured more readily than the smaller. No difference in efficiency has been found, however, in fast- and slow-water areas. With other methods, such size differentiation may be complicated further by differences of efficiency associated with various water types and other factors. In any extensive series of experiments, the efficiency of capture could not be assumed to be stable and, consequently, ignored. Knowledge concerning the relative efficiency of the method in use, i.e., the percentage of those fish present that are captured, is, therefore, necessary.

Introducing marked fish into the areas being inventoried and utilizing the percentage of marked to unmarked fish finally captured, have given estimates of the efficiency of recovery in some studies; in others, usage of one of the additional methods of recovery has furnished a check and thus an estimate of the efficiency of the routine method. The use of marked fish to estimate the efficiency of the collecting poses many problems. For instance, given (1) a section of stream, blocked off with stop seines, in which it is desired to estimate the total number of trout; and (2) a collecting method such as seining available, it is possible to--

a. Go through the section one or more times and capture a considerable number of the trout there and record this number.

b. Mark these fish and release them in the same section.

c. Go through the section again after a lapse of time. Unmarked fish and marked fish will then be captured.

If it is assumed that the fish marked and released are representative of those remaining unmarked in the section, the total population can be estimated by the proportion:

$$\frac{\text{Number caught, marked in 1st operation}}{X} = \frac{\text{Number marked, recovered}}{\text{Number unmarked caught}},$$

There is a distinct possibility, however, that those fish first captured, marked, and released, are not representative of the uncaught fish in the section: the fish caught were probably more available to the operation, owing to their holding inferior niches in the stream or for other reasons. It might be argued that fish marked and released would: (1) again be taken more readily than those remaining, thus providing too small an estimate of the population; or (2) having profited by their experience, be taken less readily than those remaining, thus providing too great an estimate of the population. The former alternative appears the more probable. It appears that this possibility can be reduced somewhat by maximizing

the time elapsing between the planting of the marked fish and the check inventory, in order to allow a more complete redistribution of marked and unmarked fish. In the Crystal Creek studies, with the electrical-shocking method, 6- to 9-day periods elapsed before the check inventories were made.

There is no assurance, however, that such precautions assure a condition in which the marked fish are representative of the unmarked fish remaining in the section. The planting of marked hatchery fish or of wild fish from other sections for a check on efficiency has been tried, but it appears to offer no advantages. To date, a completely satisfactory method of utilizing marked fish to estimate the total population of stream sections, still remains to be developed.

4. The determination of the physical set-up (location, number of streams involved, number of sections, and other features) of the experimental stream poses additional problems.

The experimental area containing the planted fish might be limited in extent to that which can be inventoried completely by the method of inventory selected. Here the range of application of the findings obviously would be less than if the results represented an entire stream or group of streams. To have the results apply to an area much larger than the sampled sections, it would appear efficient to stock a whole stream or group of streams with experimental fish, and then to set up a sampling system by which conditions over the whole area could be judged.

In order that the population of the whole stream may be estimated, the sections must be truly representative of the whole stream. This necessitates that they be random samples, selected without personal discretion or bias. They must also be numerous enough to constitute an adequate sample. If "adequate" be defined as the number of sections required to produce the mean (number of fish per section) with a given standard error, it is obvious that the number would depend upon the variability among sections of the stream. In other words, in a stream with a relatively homogeneous population from one end to the other, relatively few samples would be necessary to produce a mean with the desired degree of error; but in a stream with relatively large variations in the population in various parts of the stream, relatively many samples would be necessary. The use of a restricted, stratified, random sampling technique in such designs has been illustrated by Mottley and Embody.[1]

One attempt at least has been made to evaluate trout hatchery and stocking practices in this manner. Schuck and Kingsbury (in press) report on experiments designed to determine the effectiveness of planting fingerling brown trout in slow and in fast water. In all of five plantings, electrical inventories showed a significantly greater number surviving in fast water. Growth rates were also greatest in fast water.

Possible Experimental Program

1. One stream, perhaps 5 miles long, segregated by weirs at each end, would be stocked throughout its length.

2. Equal numbers of fish raised under each of several hatchery procedures in the experimental hatchery would be planted at one time.

3. The method of electrical shock would be used as the means of determining the relative numbers of the various groups surviving after definite periods in the stream.

4. Sample sections would be inventoried, the sample sections to be selected by dividing the entire length of stream into about 106 250-foot sections, giving each a number, and selecting the numbers at random. The sampling would probably be done efficiently by dividing the sections into fast- and slow-water sections, and stratifying the sampling by this factor, inasmuch as it is possible that differences in population between fast and slow water exist, as they did in Crystal Creek (Schuck 1945).

5. The exact number of samples for inventory would remain uncertain until the variability of population density

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[1] Mottley, C. McC., and Embody, D. R. An efficient sampling method for taking a creel census. Unpublished manuscript.

in the particular test area is determined, possibly in a preliminary experiment. In Crystal Creek, a sample of about 7 percent of the stream length sufficed to provide one unit of information, adequate to detect a difference of 10 percent in population size. On this basis, about eight 250-foot sections would be necessary in the 5-mile stream. For more critical tests of the average number of various groups surviving, however, probably more sections would be desirable.

6. A complete inventory probably would be desirable two or three times a year. Such a schedule would make it possible to obtain several replications of each planting. For each inventory, a new group of randomized sections would be drawn.

7. A creel census, if angling is permitted in the area, would be operated for the purpose of obtaining a total catch record with which to correct survival estimates.

8. Enlargement of the experimental stream system to a group of streams would enlarge greatly the range of application of the results obtained. Such streams should also be selected at random from a larger number of streams. The desirability of randomization and of efficient, modern, experimental designs for the complete set-up is illustrated by Mottley (1942). The use of such methods would ensure the proper degree of control over sources of variation and the proper number of replications. This would make it possible to be confident that if survival and growth differences between certain lots of planted trout were found, the differences were due to differences in the hatchery methods under which the fish were reared, and not to initial differences in the fish themselves; to differences associated with years, seasons, stream sections, streams, and methods of inventory; to random sampling error; or to any factor other than the one that it is desired to evaluate.

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VALUE OF HATCHERY

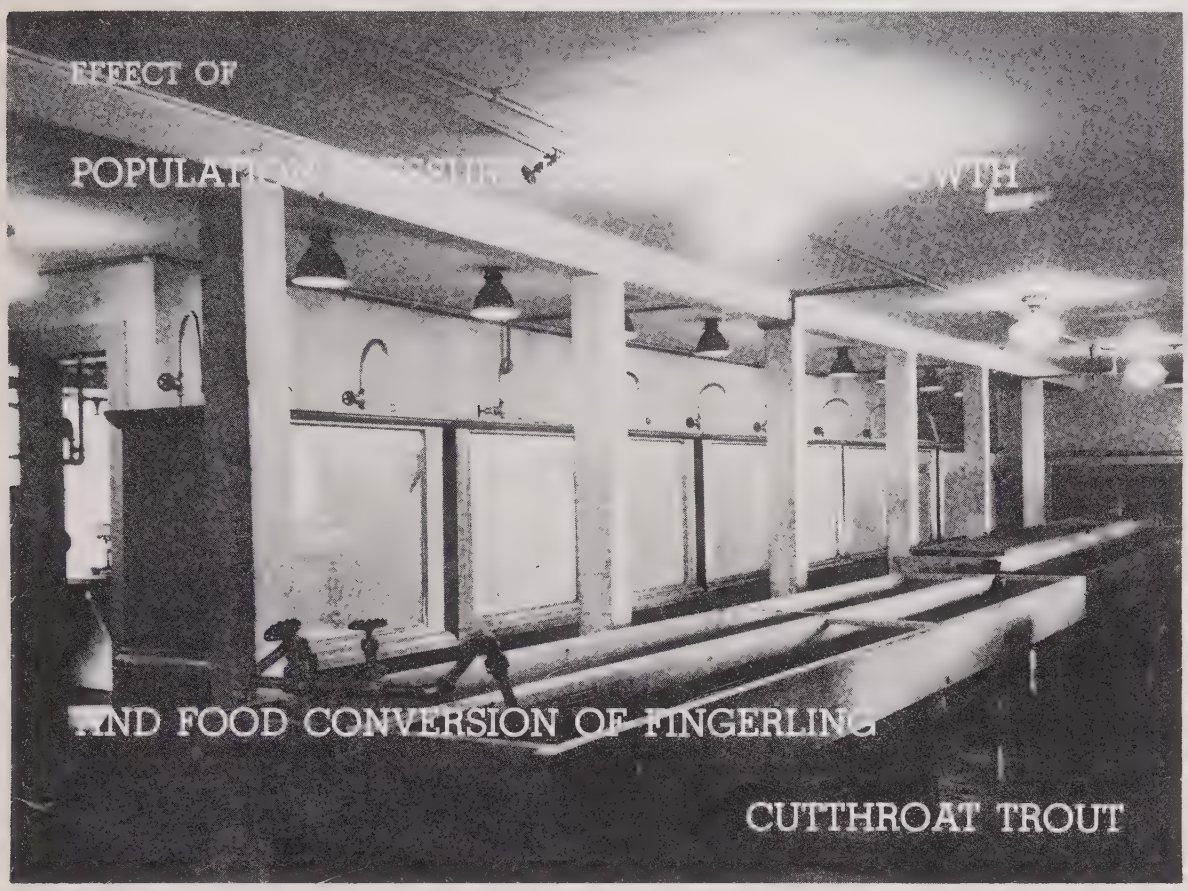
Let this one fact be understood at the very outset: There are so many fishermen in the state of Pennsylvania that should the hatcheries be closed, or even fail fully to perform their functions, trout fishing would become impossible in a matter of a few years. There would not be enough fish to make it worthwhile for a man to buy a license.

* * *

Hatchery trout do not just grow. They require a huge amount of hard work, of scientific knowledge, and of tender care. Like the young of the human race, they are frail and dependent upon others for their well-being. They are assailed by disease unless carefully protected.

And on a cold business basis, the trout that are stocked in the streams have a cash value, on the average, of 55 cents a pound.

--"From Egg to Trout Brook" by R. F. Williamson in Pennsylvania Angler 16 (2): 2. February 1947



Photos courtesy of authors.

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THE EXPERIMENT was designed to test the effect of a tenfold variation in population pressure upon the rate of growth and food conversion of fingerling cutthroat trout. The equipment and methods used were those developed by Dr. L. R. Donaldson and his associates at the School of Fisheries of the University of Washington.

See also:

Woodbury, L. A.
1939. Overcrowding trout. Prog. Fish-Cult. 45: 58-60.

Fingerling cutthroat trout in four 80-gallon aquaria were fed approximately equal amounts of food per fish. About 0.6 gallon of water per minute entered each tank at a vertical jet under 30 pounds of pressure per square inch and overflowed through a screened outlet at the surface. Two tanks contained nearly 280 fish each, and the other two tanks had 28 fish each. Fork lengths (to the nearest millimeter) of the individual fish and total weight (in grams) of the fish in each tank were determined on four occasions from July 29 to September 5, 1947. The amount of food per tank at each feeding was recorded so that food-

conversion factors could be computed. The table shows number of specimens, mean length and weight, total weight of the fish in the tank, sum of squares of deviations from mean length (Sx^2), and amount of food consumed per tank since the previous measurement.

The same kind of food was given to all tanks at a feeding. Basically, the diet used in this experiment consisted

Mean lengths and weights of fingerling cutthroat trout

		Tank 1	Tank 2	Tank 3	Tank 4	Total
7-29-47						
Number of fish		278	28	281	28	
Sx^2 of length*	mm.	11311.43	1194.68	13132.6	1042.11	
Mean length	mm.	62.4137	62.1071	60.8754	62.8214	
Mean weight	gm.	2.9245	3.0000	2.8423	3.2500	
Total weight	gm.	813	84	793	91	
8-12-47						
Number of fish		279	28	276	28	
Sx^2 of length*	mm.	19213.74	1904.68	21444.57	2063.43	
Mean length	mm.	69.1613	70.1071	67.9601	70.8571	
Mean weight	gm.	4.4229	4.1786	4.2428	4.5714	
Food consumed since last measurement	gm.	872	91	871	93	
Total weight	gm.	1234	117	1171	128	
8-26-47						
Number of fish		279	28	274	28	
Sx^2 of length*	mm.	32005.49	2784.86	33663.02	3254.43	
Mean length	mm.	79.6237	79.5714	77.7299	79.6429	
Mean weight	gm.	6.7491	6.9643	6.5328	6.7857	
Food consumed since last measurement	gm.	2115	211	2111	211	
Total weight	gm.	1883	195	1790	190	
9-5-47						
Number of fish		278	28	274	28	
Sx^2 of length*	mm.	46250.8	3752.00	49439.4	4678.68	
Mean length	mm.	86.7302	87.0000	84.7774	86.6071	
Mean weight	gm.	8.8130	8.8571	8.3248	8.5000	
Food consumed since last measurement	gm.	1550	155	1550	155	
Total weight	gm.	2450	248	2281	238	
Total food used	gm.	4537	457	4532	459	9985
Total gain in weight	gm.	1637	164	1488	147	3436
Conversion ratio: food/fish		2.7715	2.7866	3.0457	3.1224	2.906

*Sum of squares of deviations from mean length.

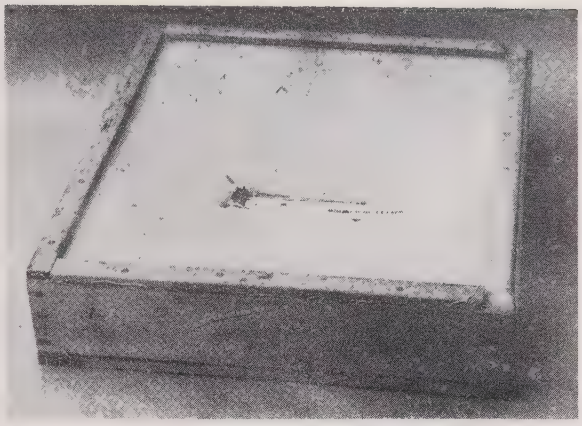
of finely ground fresh beef liver combined with a dried-meal mixture of the following ingredients:

Fish meal	15 parts
Salmon meal	15 parts
Salmon egg meal	15 parts
Liver meal	10 parts
Alfalfa leaf meal	10 parts
Tomato meal	10 parts
Feed yeast	10 parts
Wheat germ	5 parts
Kelp	5 parts
Salt	2 parts

The proportions of fresh beef liver to the meal mixture varied throughout the experiment according to the size and growth of the fish. At the beginning of the experiment equal parts of beef liver and meal were used. This was passed through a blower to obtain the proper size of food particles for the fingerling trout. At the end of the first week the proportion was changed to 70 percent beef liver and 30 percent meal. This mixture was ground through a 3/16-inch plate in the food grinder and provided a firm moist diet. After 5 weeks the proportions were changed to 24 percent beef liver, 48 percent meal, 16 percent fresh halibut scrap, 8 percent shrimp shuckings, and 4 percent canned salmon. This diet, also ground through a 3/16-inch plate, was used for the remainder of the experiment. An attempt was made to feed the fish approximately 7 percent of their body weight daily.

Mean fish lengths for the four tanks were compared by use of the "t" test as employed by Snedecor (1940). In a test of homogeneity the two crowded tanks, each containing about 280 fish, were compared with each other, and the two uncrowded tanks, each containing 28 fish, were similarly compared with each other. The two crowded tanks were then compared with the two uncrowded tanks to detect effects of crowding.

On the first three of the four measurements the mean fish-lengths in the two crowded tanks differed significantly but by progressively decreasing amounts, until at the fourth measurement the difference was no longer significant. The two uncrowded tanks at no time differed significantly from each other. In the test



Cradle used for measuring fingerlings

for which the experiment was devised, the comparison of crowded with uncrowded tanks, there was on no occasion a significant difference in the mean lengths of the two groups.

Conversion of food was at the average rate of 2.91 grams of food required to produce 1 gram of fish. The crowded fish did not differ significantly from the uncrowded fish in the conversion rates, which were 2.90 and 2.94, respectively. Food conversion was slightly, although not significantly, more efficient in the crowded fish.

General impressions obtained while caring for the fish suggested that in the uncrowded tanks the fish had greater appetites and would have eaten considerably more food than was given, whereas in the crowded tanks the fish had as much as they would readily eat. This suggests that if the fish had been offered all the food they would eat, the uncrowded fish would have received more per fish than the crowded fish, and there would doubtless have been significantly faster growth among the uncrowded fish.

In this experiment, where the amount of food per fish was kept the same for all tanks, the degree of crowding was apparently not sufficient to be harmful. A detrimental effect might be expected if crowding were too extreme. On the other hand, it might be reasoned that with a large compact body of fish there would be more efficient utilization of food than when a few fish occupied a relatively large volume of water. As no significant difference in growth or

in rate of food conversion appears in the present data, it is concluded that crowding to the extent employed in this experiment had no detectable effect upon these processes.

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COMPLETION OF FISH AND GAME SURVEY OF GUATEMALA

A second and final survey of fish and game in Guatemala was made between March 6 and May 23, 1947, under the sponsorship of the Fish and Wildlife Service, the Guatemalan government, the Smithsonian Institution, and the State Department. In this season 14,000 fish specimens were added to the 28,000 secured last year. The use of a 600-foot commercial seine, fyke nets, and similar fishing gear revealed much information concerning the relative abundance of the game fishes.

Several new species were discovered. The habits of that remarkable fish known as the "Cuatro ojo" (four-eyed fish) were studied at night by the aid of a gas lamp. This fish has such acute eyesight that it cannot be approached closely in daylight. The natives consider this fish a delicacy.

More than 180 species of fresh-water fishes were collected during the two seasons, and a report on them has been begun. No waters suitable for trout stocking were located in Guatemala. No other North American game or food fish should be considered for introduction until the possibility of using native species has been thoroughly explored.

NEW COMPOUNDS FOR THE CONTROL OF BACTERIAL GILL DISEASE

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BACTERIAL GILL DISEASE, a common epizootic among hatchery fish, can be controlled by copper sulphate dips, as stated by Davis (1946), or by prolonged treatments with Roccal, as noted by Fish (1947). The use of copper sulphate is not without danger because of variation in toxicity according to the hardness of the particular water supply; also, the toxicity and efficacy of Roccal have varied considerably in different lots. Neither copper sulphate nor Roccal will cure in one treatment a well-established epizootic of bacterial gill disease. For these reasons, a series of new disinfectants has been tested in the laboratory in an attempt to find a more effective cure and preventive for bacterial gill disease. One of these tested, pyridylmercuric acetate, was suggested by Van Horn and Katz (1946).

Gill disease was allowed to develop in one pond of blueback salmon fingerlings, Oncorhynchus nerka (Walbaum), under the surveillance of Mr. Roger E. Burrows, District Biologist at the U. S. Fish-Cultural Station, Leavenworth, Washington. The fish stopped taking food, and some floated listlessly in the water; the typical myxobacteria were consistently found on the gills, and hyperplasia of the gill epithelium was present. A group of the weaker fish, which had congregated near the drain of the pond, was selected for experimentation. Five pounds of fish--approximately 465 fish averaging slightly more than 3 inches in length--were placed in each of 20 troughs.

The treatments given these fish were administered by turning off the trough water supply and adding the required amount of pre-diluted disinfectant by means of a sprinkling can to avoid areas of hyperconcentration. An exception was made with pyridylmercuric acetate (PMA), which was merely sprinkled in dry form on the surface of the water. A paddle was used to mix thoroughly the trough water and the disinfectant. At the end of an hour, the water was turned on and the trough partially drained to flush out the disinfectant. The gills of the fish were examined daily for 3 days and again at the end of 2 weeks to determine the amount of hyperplasia and the number of characteristic bacteria present. The number of bacteria present was used as the criterion for determining the efficacy of the disinfectants.

The table shows the disinfectants and concentrations used, the number of times each disinfectant was administered, and the results. The Roccals (alkyl-dimethyl-benzyl-ammonium chlorides) were used somewhat as a control and, also, to compare

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See also:

Feustel, J. G.
1935. Gill disease checked. Prog. Fish-Cult. 6: 7-8.

Fish, F. F.
1935. Bacterial diseases of fish. Prog. Fish-Cult. 5: 1-9.

1939. Disease prevention in the trout hatchery. Prog. Fish-Cult. 43: 1-8.

variations in the toxicity and efficacy of different lots. Previously, Lot 021AJ had been found satisfactory for general hatchery use at a 1:500,000 concentration; Lot 10036 did not control gill disease at a 1:500,000 concentration but did at 1:400,000; and Lot 10129 was a new shipment which had been found quite toxic. The disinfectant listed as Roccal Cetyl is cetyldimethylbenzylammonium chloride, Roccal Dichlor is 2,4-dichlorobenzyl-dodecyldimethylammonium chloride, EMCOL is alkyl-aryl-pyridinium chlorides, and PMA is pyridylmercuric acetate.[1/]

All troughs other than the controls were treated at least once; some troughs received treatments on 3 consecutive days (the procedure recommended when using Roccal as a therapeutic). The times of treatment are indicated by the asterisk in the column "T." Each time the gill examination involved only the inside row of filaments of the first gill arch on the right side from three fish from each trough. The amount of gill hyperplasia (clubbing, which is caused by the irritation of the bacteria on the epithelial cells so that the gill filaments appear as clubs) is recorded by plus (+) signs on a horizontal line. One plus sign indicates that as many as 25 percent of the filaments observed were clubbed; two plus signs, 50 percent; three, 75 percent; and four, 100 percent. The relative number of bacteria was also estimated: one plus sign indicates that one or two clumps of bacteria were observed on the filaments examined, two indicate more, three plus signs indicate that bacteria were quite easy to find, and four indicate that bacteria were present on all filaments.

The mortality, referred to as "Mort" in the table, is of little significance except in the test of Roccal Cetyl, which is slightly toxic to infected fish at a concentration of 1:2,000,000. Figures indicate daily mortality except in the column headed "14," which shows accumulated mortality from the third to the fourteenth day.

From an examination of the data in the table it is apparent that the infection persisted in the controls for 3 days, and by the end of 2 weeks the proliferated epithelial cells had sloughed and the bacteria had become greatly reduced in number. This is a common development when infected pond fish are placed in troughs and it complicates the procedure of evaluating disinfectants. It is of interest to note that fish affected with bacterial gill disease in an outside pond at the Leavenworth Station will recover when placed in a hatchery trough. Here the water flows through the trough, carrying away free bacteria; whereas in the ponds water can recirculate many times. A high mortality would have developed in the infected fish in the pond if treatments had not been administered; the disease was easily controlled, however, by prolonged treatments with Roccal on 3 consecutive days.

Of the three batches of Roccal tested, two removed the bacteria in two treatments, while Lot 10036 failed to do so even though used in higher concentration. The data indicate that Roccal Dichlor shows promise: the bacteria were removed in one treatment at 1:500,000--unfortunately, a limited supply of the disinfectant precluded further study. Roccal Cetyl, even in the much diluted form used, was toxic to the fish and apparently failed to kill the bacteria. EMCOL, which is similar to the other cationic agents, failed to remove the bacteria in a single treatment even though used at a considerably greater concentration. The PMA appeared to be the best disinfectant tested, for it removed the bacteria at a 1:500,000 concentration in a single treatment and (judging from *in vitro* work) it probably can be used effectively at a greater dilution. It is relatively nontoxic to fish, but because it is a mercurial it will have to be tested further for evidence of cumulative toxicity.

Summary

Several disinfectants were tested on bacterial gill disease. Pyridylmercuric acetate (PMA) was the best, but because of possible mercury poisoning it should

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[1/] Roccal Cetyl and Roccal Dichlor were supplied by the Winthrop Chemical Company, Inc., the EMCOL by the Emulsol Corporation, and the PMA was supplied by the Mallinckrodt Chemical Works.

DISINFECTANT	CONCENTRATION	NUMBER OF DAYS FOLLOWING TREATMENT																	
		0		1				2				3			14				
		MORT	T	MORT	CLUB	BACT	T	MORT	CLUB	BACT	T	MORT	CLUB	BACT	MORT	CLUB	BACT		
Control	----	1		2	++ ++ ++	++ ++ ++		0	++++ ++++ +++	+++ ++ ++		1	+++ ++ +	++ + ++	5	- + +	- - -		
Control	----	11		0	+++ +++ +++	++++ ++++ ++++		0	+++ ++++ ++	++ ++++ ++++		0	++ ++ ++	+++ + ++	3	++++ - +	+++ - ++		
Roccal 021AJ	1:500,000	5	*	1	+ +++ ++	- - ++		0	++ + ++++	+ + +		0	+ + +	+ + -	0	- + +	- + -		
Roccal 021AJ	1:500,000	5	*	0	+ ++ +++	+ +++ ++	*	0	++ + ++	- - -	*	0	+++ +++ +	- - -	0	- - -	- - -		
Roccal 10036	1:400,000	7	*	1	++ ++ ++	+ + +		0	+++ +++ +	+ - -		0	++ ++ +	+ +++ -	0	- - +	- - -		
Roccal 10036	1:400,000	11	*	4	+++ +++ +	- ++ +	*	0	++ ++ ++	- + +	*	1	+ + +	- - -	0	- + -	- - -		
Roccal 10129	1:500,000	5	*	2	++ +++ -	+ + -		0	+ + +	+ + -		0	+++ - +	+ - -	0	- - -	- - -		
Roccal 10129	1:500,000	3	*	6	++ ++ +	+ + +	*	0	+++ ++ +++	- - -	*	0	+ + ++	- - -	0	- - -	- - -		
Roccal Dichlor	1:500,000	17	*	2	++ + ++	+ ++ -		0	++ + ++	- + -		0	+ + +	- - -	0	- - +	- - -		
Roccal Dichlor	1:500,000	7	*	1	+ +++ ++	+ - -	*	0	++ - +	- - -	*	0	- + +	- - -	1	- + -	- - -		
Roccal Dichlor	1:833,000	5	*	2	+ +++ ++	- - +++		0	++ + ++	- - +		0	+ ++ +++	- + ++	0	+ - +	- - -		
Roccal Dichlor	1:833,000	2	*	0	+++ ++ ++++	- + -		0	+++ ++ ++	- - -		0	++ + ++	++ - +	0	+ - -	- - -		
Roccal Cetyl	1:2,000,000	9	*	28	++ +++ ++	+++ ++ -		0	+++ + +	+++ ++ +		0	+ ++ ++	+ ++ +	0	- + -	- - -		
Roccal Cetyl	1:2,000,000	2	*	37	++ +++ ++	+ +++ +	*	0	+++ ++ +	+ - -	*	0	- ++ -	- - +	1	- - -	- - -		
EMCOL	1:100,000	1	*	1	+++ + ++	+ + -		0	- + +	- - -		0	+ ++ +	+ + -	0	- - -	- - -		
EMCOL	1:100,000	5	*	4	++++ +++ ++	- - +	*	0	+ +++ +	- - -	*	2	+ + ++	- - -	1	- - -	- - -		
P M A	1:100,000	2	*	0	+ ++ ++	- ++ +		0	+ + +	- - -		0	- + ++	- - -	0	+ - -	- - -		
P M A	1:100,000	1	*	2	++++ ++ ++	+ + +	*	0	+ + +	- - -	*	0	- + -	- - -	0	- + -	- - -		
P M A	1:500,000	0	*	0	++ ++ ++	+++ + -		0	+++ ++ -	- - -		0	+ + +	- - -	0	- + +	- - -		
P M A	1:500,000	6	*	1	+ + +	- + +	*	0	+++ ++ ++	- - -	*	0	- + +	- - -	0	+ + ++	- - -		

be tested further. Of the cationic compounds tested, 2,4-dichlorobenzyldodecyldimethylammonium chloride (Roccal Dichlor) showed the greatest promise. Of the three commercial batches of Roccal tested, one was definitely inferior.

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POND OWNERS GET FISH IN OKLAHOMA

The distribution unit of the U. S. Fish-Cultural Station at Tishomingo, Oklahoma, is capable of handling a large poundage of pondfish, and on the long trips necessary to fill the numerous applications (the majority involving 1- to 5-acre ponds) the truck is usually met by many pond owners. Recently, however, during a trip made in the area around Hugo, Oklahoma, the record number of 106 farm-pond owners met the truck. Superintendent Hubert C. Topel reports that 120 applications for bass and 115 applications for bluegills were filled in that one day.

IMPROVED METHOD FOR

ENUMERATING HATCHERY FISH POPULATIONS

George S. Hewitt and Roger E. Burrows
Fish and Wildlife Service
Leavenworth, Washington.

Taft (1933) and Griffith (1940) have described a method of fish enumeration which, with minor modifications, has been adopted as standard procedure at most hatcheries. In this method, an estimate of the number of fish is obtained by multiplying the total weight of the lot by the number of fish per pound as established from a sample. The accuracy of the estimates obtained by this method depends upon the percentage of the population sampled, the degree of variation in the size of the stock, and the bias in the sample. Though each of these factors is of considerable importance, the last one seldom is fully appreciated by the average fish-culturist.

The problem outlined at the beginning of the present investigation was to identify the sources and magnitude of the errors to be anticipated in using established methods of enumerating fingerling fish. As the work progressed, however, it became very apparent that the bias arising from the method employed in taking the sample was the basic source of a serious and unnecessary error. For this reason, the development of a method to reduce sampling errors was included in the study.

Little could be found in the available literature relative to the problem of enumerating fish. Mottley (1936) discussed the complexity of sampling and pointed out two of the major sources of error inherent in current sampling methods, namely, the tendencies of the bigger fish to occupy the upper end of the trough or raceway and to avoid capture by the dip net.

Mottley's work did much to dispel the illusion of fish-culturists who placed great confidence in estimates based upon a sample containing only a small percentage of the population. Although his work was concerned primarily with sampling fish populations to determine the total weight of the fish in a pond rather than the number of fish, the problem is essentially the same. Mottley concluded that a sample containing one-seventh of the fish in a pond would be necessary, and that the number of fish present must be known in order to estimate the total weight within 10 percent of the true value.

EVALUATION OF SAMPLING TECHNIQUES

Landlocked blueback salmon (Oncorhynchus nerka) were used throughout the following experiments, with the exception of certain experiments concerning the enumeration of fish in ponds. These particular fish were chosen because at the time of the study they provided a large, hand-counted population and because there was a marked variation in size. The average length of the fish was 5 inches; individuals measured from 2 to 7 inches in length. By actual count, there were 29,192 fish in the landlocked blueback lot. The fish used for the pond studies were blueback salmon (O. nerka) with an average length of approximately 4 inches. As these fish never had been graded, the variation in size was quite pronounced.

As evidence indicated that samples secured with a dip net were biased (chiefly because the larger fish successfully

avoided capture), the following experiment was conducted to measure this bias. Four approximately equal netfuls of fish were removed--with a dip net in the manner usually employed by fish-culturists--in succession from a tub, and the number of fish per pound was calculated for each netful. As each netful of fish was removed from the tub, the top quarter, the second quarter, the third quarter, and the bottom quarter were isolated; and the average number of fish per pound was calculated for each quarter. The results are shown in table 1. Figures listed under average per netful clearly indicate that a preponderance of smaller fish were taken in the first net, which in ordinary hatchery procedure comprises the sample used to enumerate the total population. The striking and consistent difference between the number per pound in the top and the bottom quarters of each netful removed from the tub, reveals a pronounced movement of the larger fish to the top of the net during the draining period. The average for the top quarters of the four netfuls removed from the tub is 27.3 fish per pound; whereas the average for the bottom quarters is 36.3 fish per pound. This fact has an important bearing on the accuracy of estimates obtained when fish-culturists follow the usual practice of using the top pound or so from a netful of fish for the sample.

After confirmation of the development of considerable bias in dip-net samples, an experiment was conducted to measure the quantitative effect of this bias on the accuracy of estimates obtained by the dip-net method customarily employed at hatcheries. In this method, the population of fish to be enumerated is drained and placed in a tub of water of predetermined weight, and the total weight of the fish is recorded. The fish are then stirred and a portion removed with a dip net, drained, and weighed. The number of fish per pound is calculated from this sample. The calculated number per pound is multiplied by the total weight of the fish to produce the estimate of the total number of fish.

Five separate, known populations were enumerated by the above method. The results showed that, irrespective of the size of the samples (as much as 40 percent of the entire population), the size of the population was consistently overestimated. As might be expected, the larger the sample, the more closely did the estimate approach the actual number. (See data in table 2.) Statistical analysis of the data indicates that to provide a reasonably accurate estimate of a population exhibiting a range in individual size variation comparable to the fish

TABLE 1.--A study of dip-net samples of a population

Successive netfuls as removed from tub	Number of fish per pound				
	1st quarter of netful	2d quarter of netful	3d quarter of netful	4th quarter of netful	Average for netful
1st	30	31	36	38	33.8
2d	27	29	32	37	31.3
3d	25	31	33	36	31.3
4th	27	25	28	34	28.5
Average per quarter of netful	27.3	29	32.3	36.3	

Actual number of fish ... 796
Total weight of fish ... 25.97 pounds
True average per pound ... 30.65

studied, 38 percent of the total population must be included in the sample.

A RECOMMENDED SAMPLING DEVICE

The studies previously outlined demonstrated that the usual dip-net method of sampling to obtain population estimates was grossly inaccurate. To eliminate the principal sources of error inherent in the method, the sampling device here pictured was designed and constructed.

The circular iron framework consists of a 1/4-inch rod (of the same diameter as that of the tub to be used), to which four nets of equal cross section are affixed. The side walls of the individual nets should be slightly deeper than those of the sampling tub. The nets are identical with the exception of the bottoms: three of these are partly open and one is closed. For convenience, two handles are welded to the frame, one on each side. If the usual washtub is used as a container, a gasket should be placed around the frame in such a way as to conform to the increasing diameter of the tub as the device is raised. An excellent gasket can be fashioned by dividing a rubber tire-liner lengthwise and sewing it to the circular frame. The gasket enables the operator to raise the sampler without any fish escaping around the frame. If a container with straight sides is used, no gasket is necessary. The device can be made with more sections if a smaller sample of the population is desired.

The sampler is placed on the bottom of the tub, which is then half filled with water. The fish to be sampled are poured into the tub. It seldom will be necessary to stir the fish before raising the sampler, unless an obviously unequal distribution should occur. The sampler is raised by means of handles attached to the frame. The fish captured in the net with the closed bottom are used for the sample; the fish in the three open nets fall back into the tub.

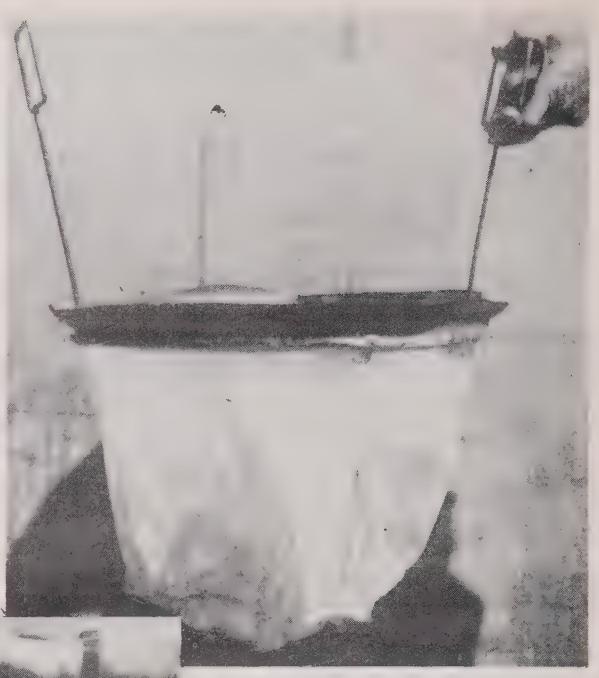
An experiment was conducted to compare results of the dip-net method with the results of the "sampler method" of enumerating fingerlings. The latter method varies from the former only in the manner in which the sample is secured. Using both methods and 25-percent samples, 15 estimates were made of a known population of 3,900 fish. To compare the results, the confidence interval--or the probable extent of the variation in the accuracy of the estimates expressed in percent--was computed for each method. For the sampler method, this range was ±3 percent; there was a confidence interval of +0.89 to +7.3 percent for the usual dip-net method. These values were computed at the 5-percent level, i.e., in only 1 out of 20 trials would the error exceed these limits.

Greater accuracy can be expected from a sample comprising a smaller percentage of the population if that population is sufficiently large so that numerous tubs can be sampled. To test the sampler method further, the lot of fish containing a counted population of 29,192 blueback salmon fingerlings--evenly distributed in 65 troughs--was studied. The fish from 24 troughs were placed in tubs and sampled with the sampling device. These 24 selected troughs were evenly distributed throughout the group, and the combined

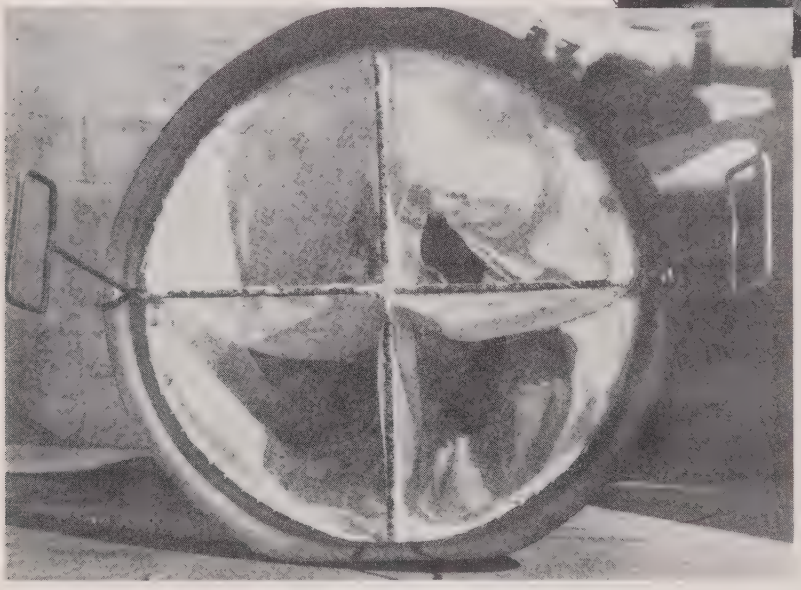
TABLE 2.--An evaluation of dip-net method of enumerating fingerlings

Population	Calculated number of fish				Actual number of fish
	8-percent sample	15-percent sample	23-percent sample	38-percent sample	
1	380	374	412	395	381
2	485	509	475	489	469
3	429	355	395	393	343
4	458	421	403	395	400
5	446	439	409	383	357
Mean	439	419	419	411	390

samples drawn from them amounted to 10 percent of the total population. The estimate of the total population derived in this manner was 29,329--an error of 137 fish, or an overestimation of only 0.47 percent. It seldom would be practicable under routine hatchery procedure to sample even 10 percent of the stock; hence the accuracy to be expected from a 5-percent sample was determined from the same data. It was found that only once in 20 trials would the error exceed 3.5 percent if at least 12 samples totaling 5 percent of the population were taken. Unfortunately, circumstances did not permit parallel enumeration of these fish by the dip-net method; so direct comparisons cannot be made.



Side view of sampler



Top view of sampler

Subsequent enumeration of fish in ponds confirmed the conclusions obtained from the above experiment. The sampler method was used to enumerate a hand-counted population of 30,464 blueback salmon that weighed 703.5 pounds. Seine hauls of about 25 pounds each were made, and every fourth haul was sampled as the fish were removed from the pond. The total poundage taken from the seven tubs sampled was 35.4, or 5.03 percent of the population. The estimate obtained from these data was 29,653 fish, or an underestimation of 2.9 percent. Slater (unpublished report, 1946), using the sampler on every third tub as the fish were removed from large raceway-type ponds, also obtained results well within the range of the method. Based on samples containing approximately 7.5 percent of the populations, Slater's estimates of two known populations of approximately 42,000 each, were in error +1.12 percent and -2.85 percent, respectively. Here again it was unfortunate that parallel data with the dip-net method could not be obtained.

Sampling fish from ponds does present complexities not encountered in trough sampling. In ponds, a variation in the manner of seining and crowding the fish

to facilitate capture can produce a marked selectivity similar to that encountered in netting fish from tubs. Accuracy may be expected in pond enumerations only if all portions of the population are adequately sampled. There is no assurance that selectivity will not occur in any method of capture; hence it is recommended that the samples be selected at equally spaced intervals from the population as the fish are removed from the pond. When troughs are selected in the hatchery for sampling, they should be chosen at equally spaced intervals.

The individual size variation of the stock is of importance in enumerating fish. If the fish were absolutely uniform in size, only one fish need be measured, irrespective of the size of the population. As the factor of size variation increases, the percentage of the total population that must be sampled to obtain a given degree of accuracy likewise increases. As the populations chosen for experimental enumeration exhibited a variation in size exceeding that normally found among hatchery fish, the sampler method should provide estimates within 3.5 percent of the true value if numerous samples totaling 5 percent of the population can be taken.

SUMMARY

Enumeration of fish populations by sampling with the dip-net method commonly used at hatcheries yields biased results because: (1) the larger fish avoid the sampling net with the consequence that a preponderance of small fish are taken, and (2) stratification according to size occurs, i.e., the larger fish move toward the top of the net during the draining period.

The first factor has been eliminated by the development of a sampling device which provides unbiased samples. The second factor, namely, the error due to the stratification within the net, may be avoided by using an entire netful for the sample.

The results obtained by the sampler method described herein were compared with a standard dip-net method of sampling commonly used at hatcheries. It was demonstrated that much greater accuracy can be expected from the use of the sampler.

For enumerating fish in ponds or in troughs, estimates within 3.5 percent of the true values can be expected if the samples are taken with the sampler at frequent, equally spaced intervals as the fish are removed, and if the total number of fish sampled amounts to at least 5 percent of the population.

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GLACIAL ACETIC ACID AND GREEN EGG MORTALITY

Kenneth E. Morton
Fall River Trout Hatchery
Bend, Oregon

The use of glacial acetic acid to determine the percentage of fertilization in green eggs was recently worked out by the writer. The test was made on 10-day-old rainbow eggs in water 46° F. These were the youngest eggs available at the time, but the writer is confident that the action of the acetic acid would be just as effective on much younger eggs.

The test is made by immersing a representative sample of green eggs in a solution of glacial acetic acid. If the pure acid is used, it will immediately turn white any growth within the egg but will not affect the balance of the egg. The strength of the solution makes no difference other than in the speed of action.

In eggs thus treated, the germ ring and the embryonic shield, which protruded from the edge of the germ ring, were clearly defined by the action of the acid. The acid had no effect whatever on the unfertile eggs; they remained in their clear, transparent state. If a truly representative sample of all green eggs is subjected to this test, a very accurate estimate can be made of the total number of eyed eggs that will develop.

It was also discovered that the action of acetic acid on dead eggs is the same as that of a strong salt solution except that, in addition to restoring the original color of the dead eggs, the acid will clearly define any growth that may have started. A count was made on 700 dead (green) eggs which were put through this test to determine whether they were fertile eggs that had died, or unfertile eggs that had merely turned white because of the slight shock received during the picking process. It was found that only 20 eggs had fish in them, and they had died at various stages of development.

The writer made this discovery during the peak of spawn-taking operations this spring (1947) and lacked the time and experienced help to make more conclusive tests. However, it seems possible that through the use of this acid test we may find a definite answer to the question: Are green eggs more tender than eyed? The writer thinks not. The writer is rather inclined to believe that unfertile eggs are more apt to turn white soon after spawning than after they have been held in the troughs for some time. These tests seem to indicate that we should concentrate our attention on faulty spawn-taking procedure, as 97.2 percent of the dead green eggs put through this test were unfertile eggs. Fertile eggs will not be killed by normal picking methods.

The advantages of the glacial acetic acid test are as follows:

1. Determination of the percent of fertilization permits greater time to work out eyed-egg allocations.
2. The efficiency of individual spawn-takers can be determined within a few days, and steps can be taken to correct any errors immediately.
3. It will enable hatcherymen to check on losses among uneyed eggs.

(Photos courtesy of the authors)

COLORADO'S GLASS FISH TANK

C. N. Feast and C. E. Hagie
Colorado Game and Fish Commission
Denver, Colorado

Colorado probably took the lead in developing fish transportation units in connection with the planting of legal-size trout from the State hatcheries. For a good many years the Game and Fish Department had used a tank truck, but its original carrying capacity was limited to about 60 or 80 pounds because long hauls were required and no satisfactory means had been devised for aerating the water in transit. Eventually oxygen drums were used and oxygen was released into the water during the haul, but this method never proved very satisfactory. Only with the adaptation of the venturi--in the discharge line of the water-circulating pump--did long hauls of large loads of fish become possible. In the same tanks that were used to transport 60 or 80 pounds of fish, we now transport 600 to 1,000 pounds to the load.

The glass tank shown in the accompanying picture was designed primarily as an educational medium, a means of bringing to Colorado's people an appreciation and understanding of the problems involved in the rearing and distribution of trout on a large scale. It is used mainly for exhibition purposes. We attempt to make this unit available at the State Fair, county fairs, sportsmen's shows, and other places where large numbers of people gather. It is also used as one of the units of our regular distribution system

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See also:

Copeland, T. H.
1947. Fish distribution units. Prog. Fish-Cult. 9 (4): 193-202.

when all our other equipment is in operation. Naturally, a little more care is required for the driving of this tank over the rough roads than for the metal tanks, and for this reason it is the last unit to be brought into operation.

The tank body of the truck is built of heat-treated glass plates, 1 inch thick. It is 84 inches long, 44 inches wide, and 30 inches deep. (All measurements are outside measurements.) The rim and splash boards are made of plastic. The glass parts are fitted together as indicated in the picture--by being bolted against rubber cushioning. The entire cost of the tank is $3,812.51.

We consider the glass tank one of our most effective mediums in educating the public in regard to our fish-production and distribution activities.

POWER EGG PICKER

Richard J. McMullen
Fish and Wildlife Service
Manchester, Iowa.

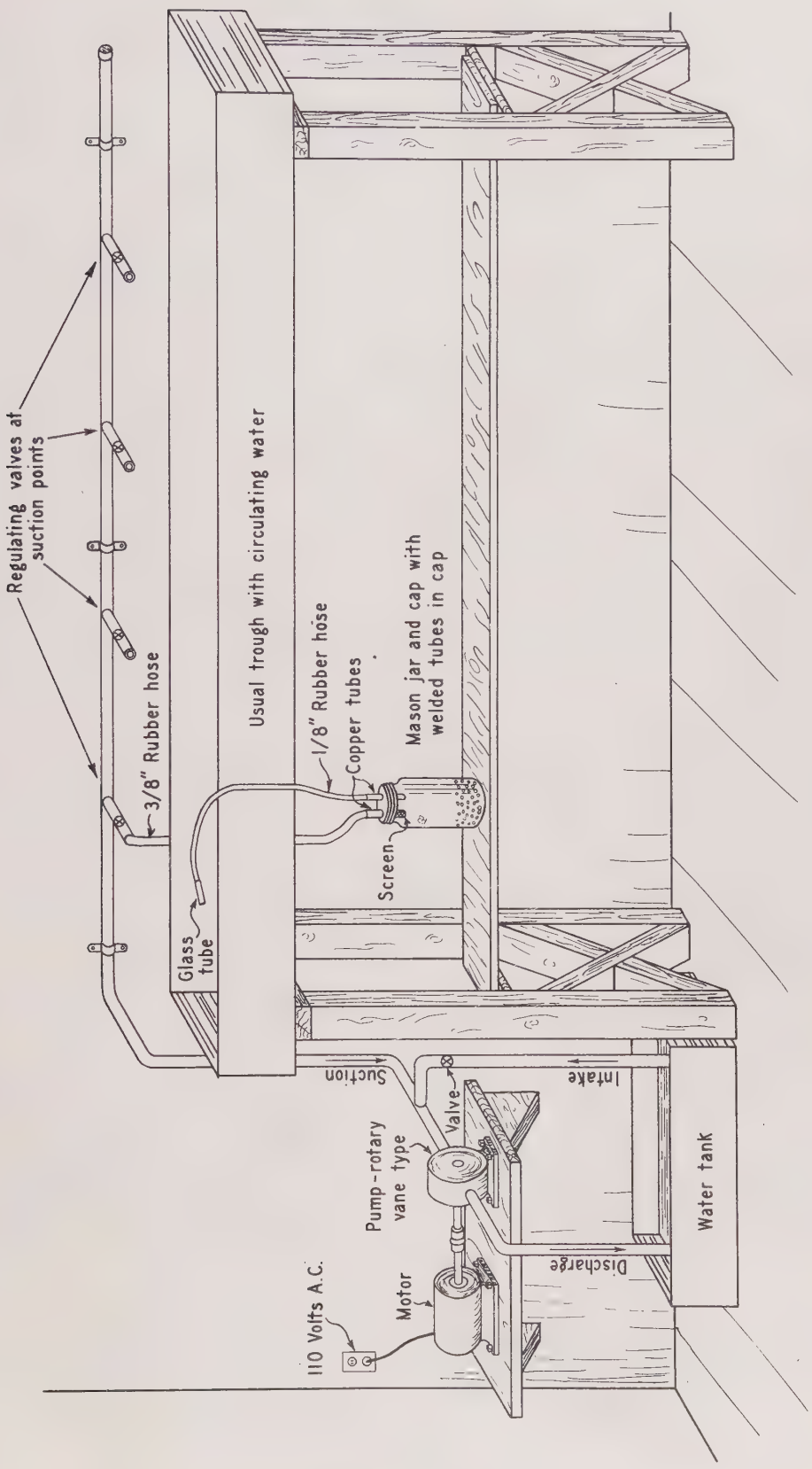
Picking eggs by hand is a slow process. The power egg picker has been devised to replace the old method of hand-picking with bulb or tweezers.

Suction from the electric water pump, operating through the 3/8-inch pipe line that extends 4 or 5 inches above the trough and then through the 3/8-inch rubber hose, creates a vacuum in the 2-quart mason jar. The vacuum in the jar, in turn, exerts suction through the 1/8-inch rubber hose, which ends in a 6-inch glass tube. Bad eggs are picked up with the glass tube and drawn into the jar, which may be emptied when about three-quarters full.

The operator of the egg-picking apparatus regulates the speed of his work by means of the pipe-line valve. Such valves may be set at 2-foot intervals. The number of jars will be determined by the amount of room available for men to work.

The plan of construction for the apparatus is shown in the diagram. Piping and construction may be adapted to conditions in the station.

A slow process.



POWER EGG-PICKER

THE HATCHERY LOG-BOOK

F. Pells
Lloyds Creek Hatchery
Cultus Lake, British Columbia

The difficulties that are frequently experienced by those engaged in the distribution of fish eggs from an eyeing station, especially the difficulties in regard to the exact stage of development of eggs prior to their shipment, may be overcome by keeping a hatchery log-book.

A simple loose-leaf folder containing ruled sheets will be suitable. Each sheet is then so apportioned that space for two or three entries may be available for each of 60 to 90 days. Each sheet will be allocated for one particular lot of eggs. All data pertaining to a particular lot--species, number of eggs, where collected, by whom, condition, losses, distribution notes, and any other remarks that may be useful for future reference--will be entered on its sheet; each day the number of heat units gained will be entered and computed serially.

After each day's eggs have been received at the hatchery, these are recorded in the log-book. At the close of each succeeding day, the maximum and minimum temperatures are recorded and the number of units gained is charged against each lot. (The number of units is derived by using the formula: the sum of maximum and minimum water temperatures divided by 2, minus 32.) By this simple method it is possible to keep an accurate check on the daily development of each lot of eggs.

It has been found at Lloyds Creek that trout eggs, after having accumulated the indicated number of units, will be in the following stages:

Number of units	Stage of development
160	Eggs may be picked over carefully and the infertile removed.
300 ± 10	Eggs are fully eyed.
300 to 380	Eggs may be shipped long distances.
380 to 450	Eggs may be shipped short distances.
500 ± 20	Eggs will be hatching.
900 ± 20	Fry will be free swimming.

The advantages of using this system are:

(1) Each lot of eggs can be "first picked" at the correct time and before there can develop on the infertile eggs any fungus which might "ball up" and infect or smother fertile eggs. Since this system was adopted at the Lloyds Creek hatchery, loss from fungus has been unknown.

(2) When a hatchery manager has such a log-book for reference, it is possible to estimate within a few days when each shipment may be made. A final notice can be sent just prior to shipment; thus the consignee will receive ample warning and be prepared for the consignment of eggs.

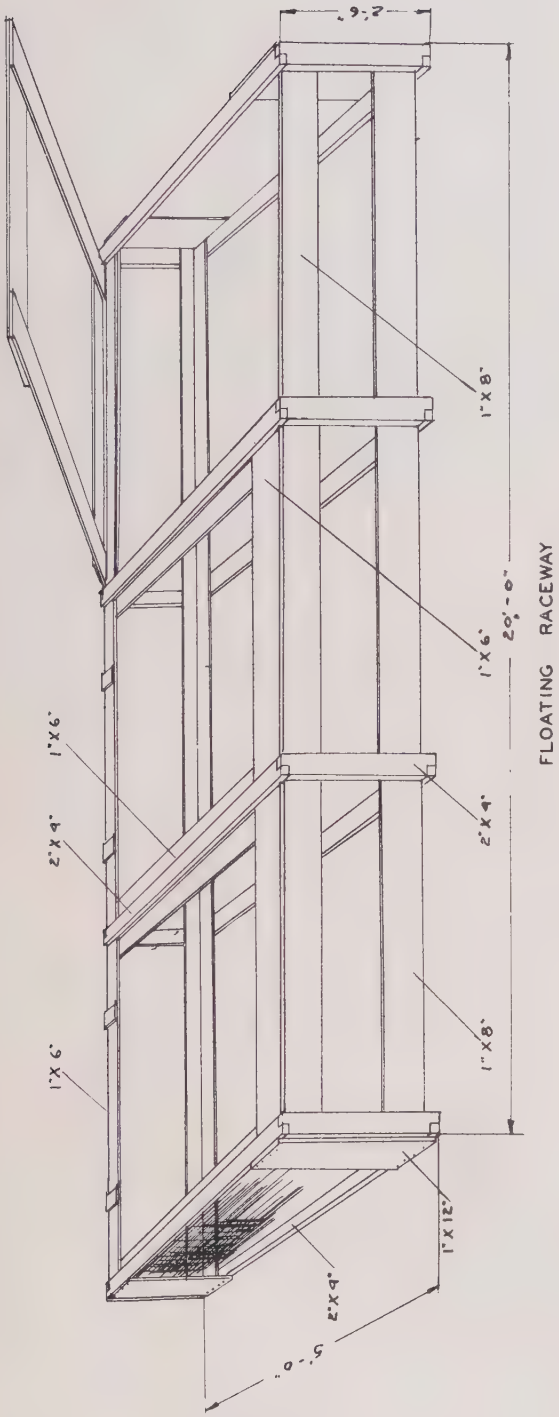
(3) When shipments of eyed eggs are sent annually to a certain destination and it is found that the initial shipment has been received in "too advanced" condition, a notation is made on that record and the following season eggs less advanced by a certain number of units can be sent.

(4) The troughs intended to hold any fry that are to be raised, can be made ready within reasonable time. This decreases the danger of an unexpected hatch, which might result in numbers of fry going down the waste pipe before the screens are installed.

In simple terms, the log-book means running a fish hatchery in an orderly manner instead of by "rule of thumb."

TROUT IN A FLOATING RACEWAY

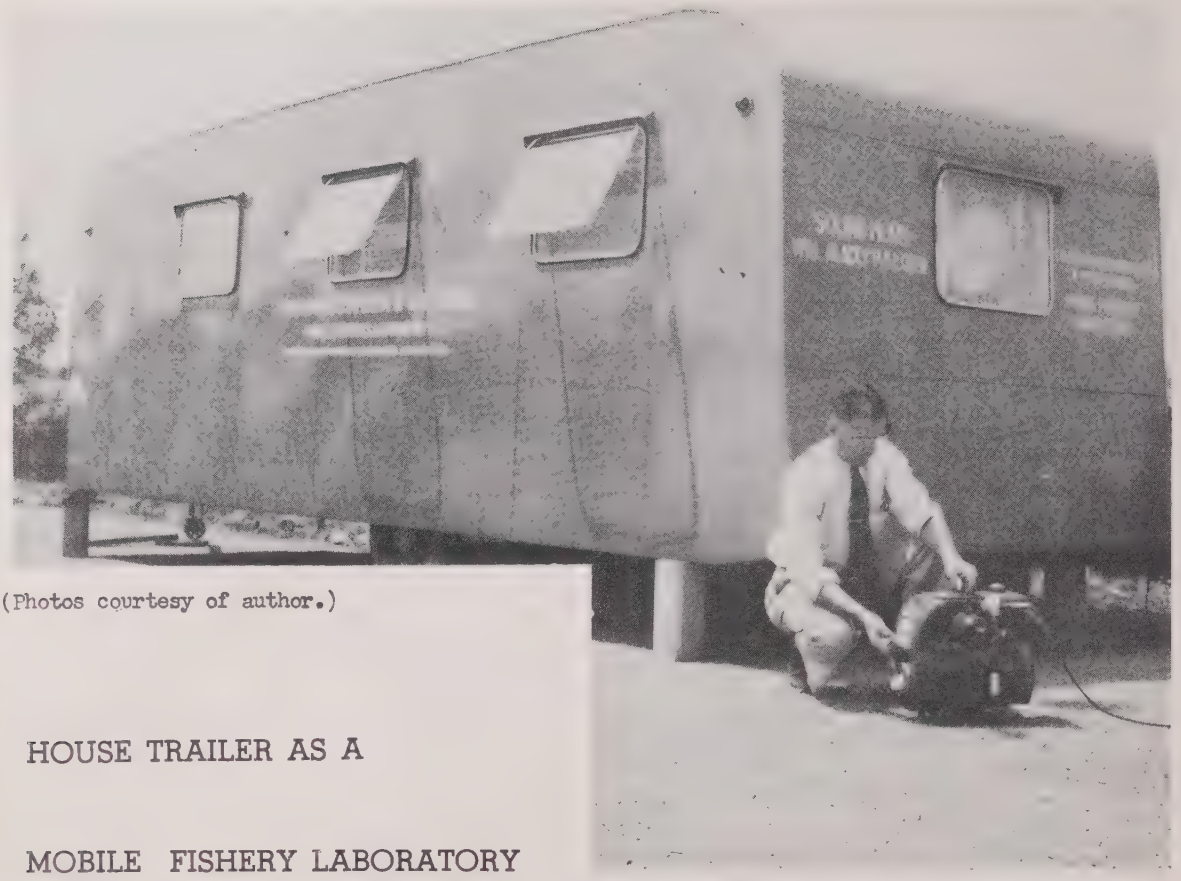
C. F. Culler
Fish and Wildlife Service
Minneapolis, Minnesota



To observe its possibilities for increased production of legal-sized trout, experiments with the floating raceway have been begun at the U. S. Fish-Cultural Station at Genoa, Wisconsin, where only warm-water fishes have been propagated in the past. A 1½-acre brood pond at this station receives its water supply from an artesian well. The flow is approximately 300 gallons a minute, and the temperature averages 52°. Water 20 to 30 feet from the well often freezes over at very low temperatures.

In the fall of 1946, a floating raceway (see drawing) was stocked with 1,500 brown trout, 4 to 5 inches long and weighing 57 pounds 11 ounces. Twice a day these fish were given the standard Cortland No. 6 diet. When they were distributed (April 1, 1947), these trout weighed 148 pounds--a gain of about 257 percent.

It is planned to utilize at least four floating raceways during the winter of 1947-48. More definite information in regard to the rate of growth (weight and length) will indicate more conclusively the value of the floating raceway at stations like the Genoa hatchery.



(Photos courtesy of author.)

HOUSE TRAILER AS A MOBILE FISHERY LABORATORY

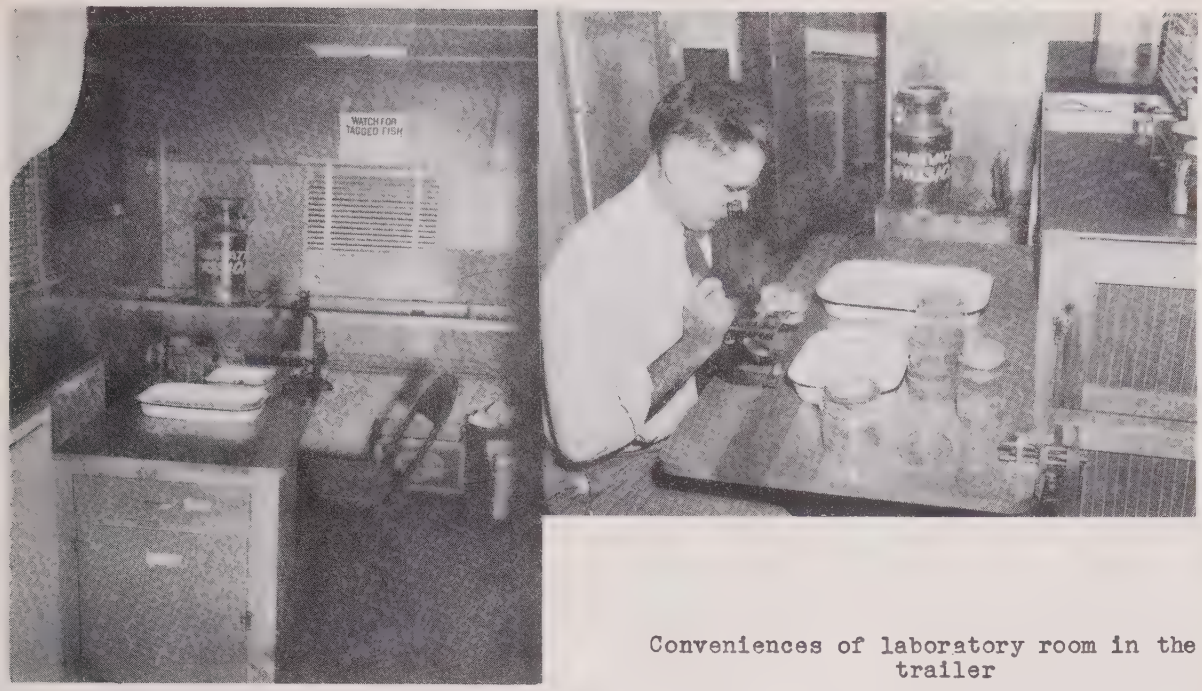
E. A. Seaman
West Virginia Conservation Commission
Charleston, West Virginia

In States where laboratory facilities are not available, or where it is unwise to spend funds for permanent laboratories which may not be used except at occasional periods, a mobile laboratory may solve the problem. In West Virginia we have used a house trailer as a laboratory for three seasons and have found it very helpful.

The greatest advantage of a mobile fishery laboratory is in having laboratory materials available near locations where field surveys are being conducted. There is little need for moving the unit frequently, for field work can be carried on in at least a 50- or 75-mile radius and a reasonable traveling distance is still maintained. Aside from its use as a laboratory, the trailer is helpful as a storage room. Fish collections can be stored until we are ready to work them over. The trailer laboratory may be occupied in all kinds of weather, both winter and summer.

Our trailer is equipped with a kerosene stove for heat and a small portable electric generator for lights at night. The unit is divided into two rooms. The original bedroom of the house trailer serves as a field office, and in this room are kept maps, filing cabinets for records, and literature. The other room, the former kitchen and living-room, is the laboratory and storage room.

This particular trailer is a Place Trailer. The over-all length is about



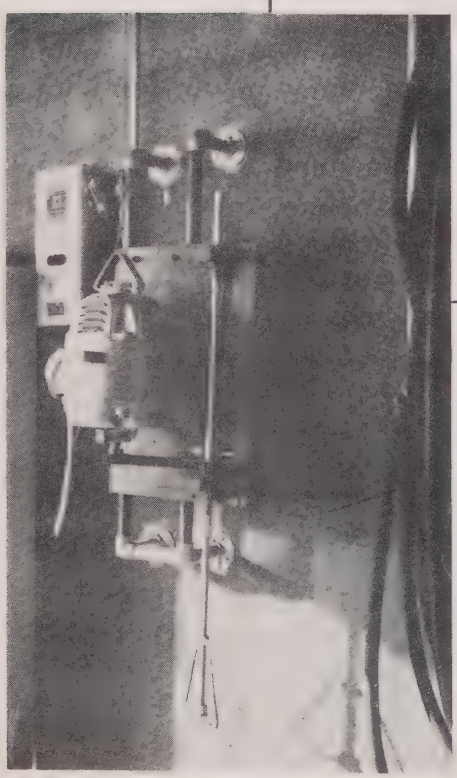
Conveniences of laboratory room in the trailer

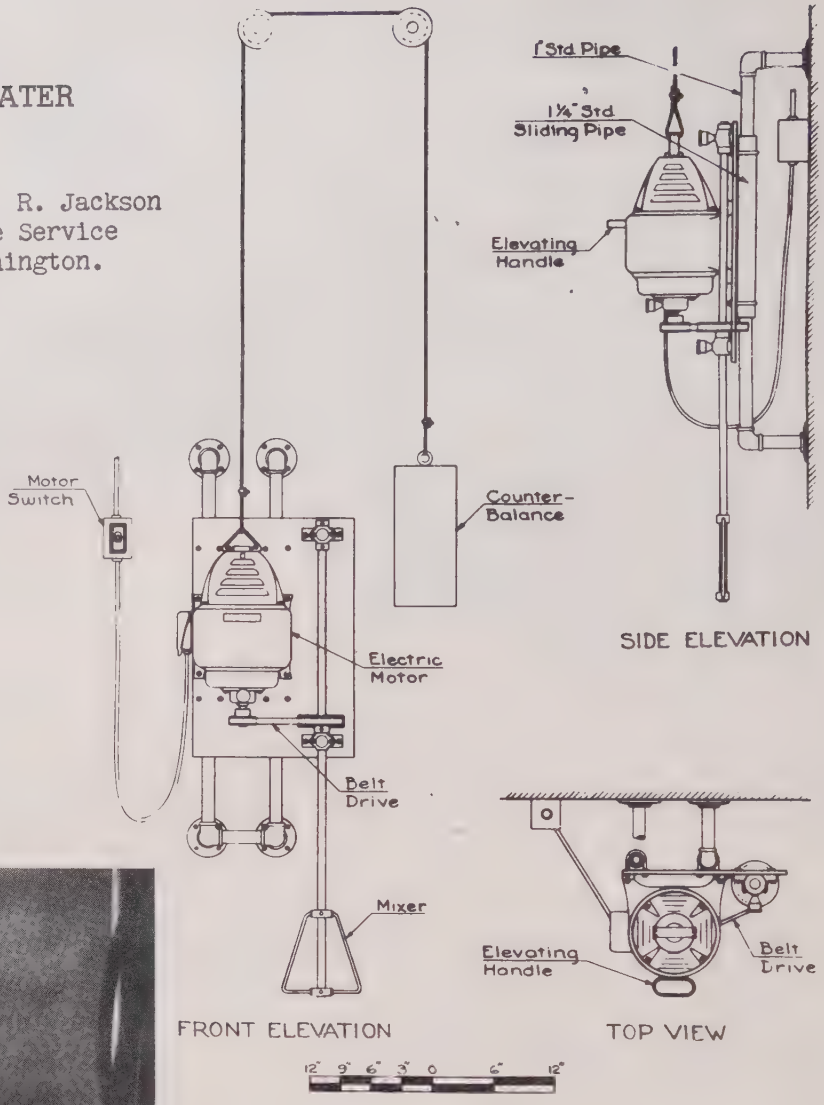
24 feet, the body is of steel framework, the exterior is of aluminum, and the interior is of plywood construction. The trailer, though appearing heavy and cumbersome, is easily pulled over the highest mountains in the State with a passenger car. Two ceiling vents in the laboratory room are of great help in ventilating the trailer. This is necessary when formalin fumes become excessive.

The trailer laboratory often is used for field staff conferences. Such use "localizes" the discussions of field problems and at the same time cuts down the great amount of travel field men must often cover for conferences. At various times the mobile laboratory is quite useful for public demonstrations. Sportsmen's organizations have opportunity to see what we are doing and frequently take a vital interest in field studies. The mobile field office has proved very worthwhile. Notes taken in the field can be transposed into our regular filing system, maps can be worked over, and then a small reference library available in the office makes for an ideal field set-up.

FISH-FOOD BEATER

J. E. Manning and C. R. Jackson
Fish and Wildlife Service
Leavenworth, Washington.





The fish-food mixer at the U. S. Fish-Cultural Station at Leavenworth has a capacity of 1,000 pounds. Frequently, however, there is need to mix smaller amounts of food. The beater pictured here has been devised to meet this situation.

Experience has shown that food should not be beaten too long, and that slow rotation of the beater is preferable in order to avoid breaking down the food where a bind is impossible.

COMMENTS

AMAKANATA HATCHERY
Calhoun, Georgia
Sept. 8th, 1947

Editor, The Progressive Fish-Culturist,
U. S. Fish & Wildlife Service,
Chicago 54, Illinois.

Dear Sir:

Just as a matter of information to you, some three weeks ago we were going through North Carolina with a full truck load of fingerling bass (both kinds), bream (bluegill and shell-cracker), and crappie--a total of some 12,000 fish.

Just about daybreak they went through a section that had just been dusted with DDT for army worm. It was rather hot, dry and dusty. The boys noticed some dust whirling around the truck from fields and roads but thought nothing of it. In two hours every fish on the truck was dead.

Later, I checked at our hatchery and found that as low as one part per million of DDT was fatal to each of our five species in about two hours.

Also know of one lake near Macon that lost all of their fish early in summer and am pretty sure it was DDT, as it was located at a dairy where they had sprayed cattle with DDT.

Have your boys reported any trouble along this line?

It strikes me that, as toxic as DDT seems to be to fish, promiscuous use of DDT--and other high-powered poisons recently developed and in process now of being developed--is going to cost us all of our fish in lakes and streams, as well as bees and other useful insects.

If you run into any information on this, I would appreciate hearing from you. In my opinion this is going to be very serious to fish culture in the near future. What do you think?

Kind regards and best wishes.

Very truly yours,

/s/ Jas. H. Reeve.

P.S. This has been one of our best years yet in production and distribution, and this poison matter has me worried.

Have you had any similar experience? Have you witnessed any ill effects upon fish during efforts to control obnoxious plants, insects, or other forms of life with this or similar materials?

PROVINCIAL ADMINISTRATION OF THE
CAPE OF GOOD HOPE
Inland Fisheries Department

P. O. Box 152
Stellenbosch
7th August, 1947

Sir,

As our fish cultural techniques are largely based on American practice, you will appreciate the value of the Progressive Fish Culturist to us.

For future reference I wish to explain the position of fisheries in general in this Province and of this Department in particular. By the Act of Union in 1910 the control of inland fisheries, among other services, was vested in the four Provinces. At this time there were two trout Hatcheries in the Cape Province. The Pirie Hatchery, Kingwilliamstown, a private institution under the control of the Frontier Acclimatisation Society, established as far back as 1902 and the Government Trout Hatchery, Jonkershoek, established by the Agricultural Department of the Old Cape Government. These institutions continued in operation after Union, but the chief interest in fisheries was from the sporting aspect, and trout remained the most important species of exotic fish.

It soon became apparent, however, that few rivers in this Province were suitable for trout and attention became centered on the importation and acclimatisation of other exotic species. Early importations included Perch, Carp and Tench. In 1927 Largemouth Bass were introduced and this was followed by the acclimatisation of Smallmouth Bass, Spotted Bass and Bluegill Sunfish. These endeavours have been fully described by Harrison.

With the large variety of fish available for stocking our rivers which are poor in indigenous fish, the rapid development of our Hatcheries followed. From a purely trout Hatchery, Jonkershoek was expanded to permit of the culture of some 15 species of indigenous and exotic fishes. Pond acreage was increased, buildings erected and additional staff appointed. In 1946 a Department of Inland Fisheries of the Cape Province was created which controls not only the Jonkershoek but also the Pirie Hatchery which was subsequently acquired. Fisheries personnel numbers some 4 professional officers, 6 fish culturists, 3 administrative officers and 23 non-European staff. The activities of our Department include the culture and distribution of fish, stocking and maintenance of public waters, research on the above-mentioned problems and publicity and educational work.

I am, Sir,
Your obedient servant,

/s/ D. Hey
Director of Inland Fisheries.

The Editor
The Progressive Fish Culturist,
Fish and Wildlife Service,
Merchandise Mart,
Chicago 54,
Illinois, U.S.A.

The central office of the Fish and Wildlife Service has now been returned to Washington, D. C. Correspondence and manuscripts should be directed to the Editor, PROGRESSIVE FISH-CULTURIST, Interior Building, Washington 25, D. C.

RELATING TO PUBLICATIONS

REPRINTS

ANILINE DYE IN AQUATIC WEED CONTROL

George Eicher
Arizona Game and Fish Commission,
Phoenix, Arizona.

Since the inception of fisheries management in fresh water, men have striven to develop methods of controlling aquatic vegetation. Although a certain amount of water weed is desirable for fishing waters, overabundance of such plants invariably leads to trouble of some sort.

Aquatic plants may cause waters to become difficult to fish, and reduced fishing loads often lead to overpopulations, particularly of warm water species. Overpopulations are also indirectly caused by weeds through providing too good cover for young fish which should normally provide a significant part of the diet of large fish, particularly of bass.

Anyone who has worked with aquatic plants has noted that clear, shallow lakes are particularly susceptible to weed growths. Rooted plants are unable to thrive in deep water because light does not reach them in sufficient quantity to promote photosynthesis. Neither do they grow in turbid waters and for the same reason. The writer has found that even slight muddying of the water in a stream is enough to cause photosynthesis to drop off in plants present and to cause a high pH to fall rapidly.

In the summer of 1944 when the writer was striving to arrive at a solution to the weed problem in many Arizona waters, the idea was conceived of artificially darkening weedy waters so as to cut down on the amount of light reaching the plants, thus inhibiting their growth. The obvious agent for the purpose was a dye of some sort.

At first glance the cost seemed to be too great to overcome. In laboratory quantities, standard dyes or stains such as nigrosine sold for about $15.00 a pound. However on contacting several producers of dyestuffs, it was found that the same nigrosine could be purchased for 36 cents a pound in 100 pound lots. Other black dyes were in the same price range, although somewhat higher. Samples of Ox intense black, Putnam's fadeless black, F and S neutral black and National nigrosine were diluted to one part per million of water and placed in a well-spaced row on the top of a rock wall in the strong Arizona sunshine in January.

Putnam's fadeless black was noticeably lighter in shading at this dilution than the other three, which were more or less uniform. In three days the Ox intense black and Putnam's fadeless black had faded almost completely out, while the F and S neutral black and National nigrosine were apparently unchanged in intensity. After three months the neutral black was slightly faded, while the nigrosine had virtually retained its original appearance.

In the meantime, after a few weeks' trial had indicated that the nigrosine was holding up best, a larger sample of

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Reprinted, with illustration, from Journal of Wildlife Management 11 (3): 193-197. July 1947.

this was ordered and two ponds in the Hunt Bass Hatchery, some ten miles from Phoenix, were treated. One of these is a half acre and the other some three acres in surface area. Both have steep sloping sides over most of the shore, with occasional large shoal areas. Depth of the water at the dams is approximately 16 feet. All ponds in this hatchery are of the same character and have about the same depth at the dams. Conditions are excellent for weeds, which thrive even through the winter months.

The half-acre pond selected for trial is designated Number Eight in the hatchery plan and the three-acre one is Number Six. On January 17, one pound of nigrosine was placed in Number Eight, lowering its visibility from 14 feet to four feet by Secchi disc reading. Ten pounds of nigrosine in Number Six lowered its visibility from 13 feet to six feet.

For the next three months this concentration was maintained in the two ponds, although it was necessary to add dye from time to time to compensate for dilution occasioned by water running through the ponds. In addition to inhibition of weed growth, some unlooked-for results were obtained. Near the end of April a great amount of zooplankton and phytoplankton developed in the two treated ponds, causing them to become markedly more turbid than were the untreated ones. This was caused possibly by decay of organic material on the bottom in the absence of light. The condition prevailed for only a month, however, after which the ponds stayed relatively clear.

Darkening of the waters also reduced the temperatures in the lower levels of the ponds. Evidently the infrared rays were kept from penetrating very far below the surface. Following is a tabulation of temperature readings from the surface and from a 15 foot level in each pond.

Pond	Surface Temperature	Temperature 15 ft. depth
2	77°	71°
3	76°	71°
*6	77°	65°
7	77°	73°
*8	77°	68°

*Treated.

By May it was decided that the treatment was demonstrating itself successful enough to warrant proceeding on a larger scale. Enough dye was ordered to treat Ashurst Lake, an alkaline problem water of static qualities, and Granite Basin Lake, another static water that had caused trouble for trout through alkalinity. Acting on indications gained from the experimental work done at the Hunt Bass Hatchery, these lakes were treated at the rate of ten pounds per acre. Treatment was calculated in pounds per acre rather than in parts per million because the nature of the dye's action makes this a more constant figure. In other words, deep lakes need less per unit volume than shallow ones because the cumulative effect of depth compensates for the reduced concentration.

Shortly after application, however, it was found that concentrations effective at the bass hatchery were not sufficient for the clearer water of the treated lakes. Visibility in Ashurst Lake was lowered to only eight feet from its original 14 and Granite Basin Lake was lowered to seven from an original 16. It was not possible nor practical to further treat Ashurst Lake because of the size, but 50 per cent more dye was applied to Granite Basin Lake, which has a surface area of but 11 acres.

In the interim, the pH of these two waters had risen from neutral to 9.5 in Ashurst and to 9.6 in Granite Basin, a normal springtime phenomenom in these waters caused by increased photosynthesis of the aquatic plants removing carbon dioxide and thus resulting in bicarbonates breaking down into alkaline carbonates. Ashurst Lake never rose any higher during the summer, although conditions were better for weeds and alkalinity than in the previous year when the pH rose to above 10.2, and the aquatic vegetation was much inhibited in the deeper water. After the second application the pH in Granite Basin Lake dropped to 7.6 and declined below that figure the rest of the summer. Long tendrils of Potamogeton crispus, the dominant weed species in this lake, in water over six feet in depth, turned white and dropped to the bottom. The second application lowered the visibility to four feet. By September the concentration of dye in each lake

Aerial view of Ashurst Lake in the foreground 18 months after treatment with dye. Note lighter color of untreated lakes in background.

was apparently about 60 per cent of that at time of application.

In the treatment of Ashurst Lake a great deal about lake currents was learned that could be of value to anyone engaged in the treatment of lakes with herbicides, fertilizers, fish poisons or any soluble substances. As before stated, Ashurst Lake is a body of water of some 200 acres. Maximum depth is 18 feet and the average depth is about 10 feet. Due to this shallow condition, it is in a constant state of turnover.

As the dye was not known to have been used previously, methods of application had to be worked out. First tried was the trolling of bags of dye in back of boats, but the substance immediately formed a large lump in the bag and dissolved quite slowly. Then bags were placed in the water at strategic points. This resulted in rapid spread of the dye, but the rate of solution was still slow. Finally the simple method of shovelling the dye into the water on the rocky bottom at points was tried and found to be most effective. In less than 24 hours the dye was not only dissolved, but completely dispersed throughout the lake. Secchi disc readings found the concentrations uniform over all of the lake in less than 24 hours after the dye had been shoveled into the water.

The rapid diffusion of the dye indicated the tremendous amount of current in a lake of this type. For illustration: on one afternoon 350 pounds of dye were dumped in the water at one point. A streak of dark water, clearly discernible at the surface, immediately started moving

across the bottom of the lake, and in less than an hour had reached entirely across to the far beach, some 1000 yards away. Other streaks fanned out in other directions at equal speeds. All of the dye seemed to travel along the bottom first. By the next morning at nine o' clock, the lake was uniformly colored. This indicated the rate at which solutions can be expected to cover a lake, an important item in the use of poisons, such as rotenone.

The dye project was more or less dropped in 1946 because it was deemed too expensive for the larger bodies of water which were the ones in which the department was particularly concerned. Some interesting and unexpected results of the 1945 treatment developed in 1946, however. Early spring found the weeds in Granite Basin Lake much inhibited and the dye still about 50 per cent of original strength. The pH of the water never reached lethal height all summer.

Ashurst Lake provided more evidence of the dye's effects. Although the water level was three feet lower than in 1945, no weeds reached the surface and all were much inhibited over the entire lake. In this lake as well as in Granite Basin, the weeds appeared to lack strength to go to the surface, instead feebly growing over each other horizontally near the bottom. In this lake also, the dye seemed to be about 50 per cent of original strength a year after application.

This delayed effect of the dye in the weeds is somewhat difficult to explain. It would seem that results should be greatest at first when the dye is strongest. However it is possible that the concentration was always too weak to cause any lethal exclusion of light from the plants, and it was cumulative starvation that produced the weakened condition the following spring. Or the original application might have been made too late in the spring of 1945, after the weeds were too far advanced. Perhaps the time to treat with dye would be in the fall, so that the weeds are denied light from the start in the spring.

Final results in the hatchery ponds near Phoenix were not conclusive, although it seemed that after the water was fertilized and temperatures exceeded 85°F. the weeds came on in spite of the dye. It was difficult to evaluate the true results, as fresh water was run through the ponds continuously for a month before draining, diluting out the dye completely. As soon as the water cleared, the weeds came on with a rush.

It would seem that this method of weed control is of sufficient promise to warrant further experimentation. While it seems too expensive for larger waters, it might be of value in small important ponds. It might be much more effective and for a longer period of time elsewhere than in the southwest, where over 300 cloudless days per year are experienced, and the piercing rays of the sun tend to encourage weed growth and to destroy dye. The tenacity of the nigrosine dye is somewhat astonishing even in Arizona, however. Eighteen months after Ashurst Lake was treated, it was still at least 40 per cent of original darkness. As the Myriophyllum, dominant in this lake, was kept from maturing, it is possible that 1947 will see a further reduction of weeds in this lake, regardless of any remaining dye.

SUMMARY

1. Aniline dye has been tried in Arizona as an inhibiting agent for aquatic plants through exclusion of light.

2. Out of several dyestuffs tested, nigrosine was found to be cheapest and most permanent.

3. By experiment it was found that darkening of ponds caused lowering of the bottom temperature and a temporary increase in plankton.

4. Dye was applied to two lakes at the rate of 10 pounds per acre, which was found to be insufficient. More was later added to one of the lakes.

5. The best method of application was found to be dumping of the dye in shallow water at points. Dispersal was complete in a 200-acre lake in less than 24 hours.

6. Greatest effect of the dye was noted the following year when normally semi-emergent weeds failed to reach the surface.

7. The method needs more experimentation in waters of more cloudy and cooler regions.

THE ELECTRIC "SHOCKER" AND ITS USE IN MICHIGAN STREAMS

David S. Shetter
Institute for Fisheries Research

For the last 20 years fisheries research workers interested in stream-inhabiting game fish have sought to perfect methods for estimating populations of stream fish. An efficient set of tools for performing this task appears to be at hand in the form of the electric "shocker."

The use of electricity for stream population studies seems to have originated in eastern Germany. The writer[1] in 1938 translated and reviewed a short article from a German fisheries publication which described the electrical equipment needed. This article also listed the standing crop of trout and its value, for certain Bavarian trout streams in three different years. Biologists and technicians connected with the New York State Conservation Department assembled and employed the shocker in that state, first in 1939 (Haskell, 1939[2]; Haskell and Zilliox, 1940[3]).

First Used in Michigan in 1942

For various reasons, Michigan did not obtain the necessary equipment until September, 1941. With the advice of David C. Haskell of the New York State Conservation Department, and through the assistance of Dr. P. I. Tack of Michigan State College, and Dr. J. W. Leonard, the first resident biologist at the Hunt Creek Fisheries Experiment Station, the Conservation Department's first "shocker" was operated on Hunt Creek in midsummer of 1942. The original unit has received much use since then, and as there is an increasing demand, both from the biological staff and the hatchery personnel, for the services of this type of gear, an additional unit of higher wattage was acquired and placed in use last summer.

C. M. FLATEN PHOTOS

Electrode, rectangular in shape, used with the "shocker"

The source of power is a 1-H.P. gasoline motor which drives a generator of 500 watts capacity. The normal current varies between 1½ and 2½ amperes, depending upon the conductivity of the water

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Reprinted, with illustrations, from Michigan Conservation 16 (9): 8-10. October 1947.

[1] Shetter, David S. 1938. Review--Hager, Franz: Use of electricity in fishing wild trout streams. U. S. Bur. of Fisheries, Memorandum 1-131, "The Progressive Fish Culturist," No. 36, Feb.-March, 1938, pp. 32-33.

[2] Haskell, David C. 1940. An electrical method of collecting fish. Trans. Am. Fish. Soc., Vol. 69, 1939, pp. 210-215.

[3] Haskell, David C. and Robert G. Zilliox. 1941. Further developments of the electrical method of collecting fish. Trans. Am. Fish. Soc. Vol. 70, 1940, pp. 404-409.

and the distance between the electrodes. The motor and generator are mounted on a carrying frame which can be portaged by two men, or rested in the bottom of a boat. The electrical current is conducted to the water through a rubber-covered two-wire cable to a pair of electrodes which are attached to wooden handles. As each electrode is connected to one pole of the generator, this forces the electrical current to use the water as a pathway in completing the circuit when the electrodes are submerged in the water. Depending on the shape and size of the electrodes and the depth of the water, the electrified field appears to be similar in shape (when viewed from above, and judging by the actions of the fish) to the conventional diagrams of fields of attraction around two magnetic poles. Any fish which enters the electrified field is momentarily stunned and may be picked up with a scap net. Apparently the rapid reversal of electrical current flow in an AC circuit affects their nervous system. The larger fish succumb readily to the "shocker," but the electrodes must be close together to knock out small fish (fingerlings and fry) since their smaller bodies do not absorb as great a portion of the electrical current as do the larger fish.

In field operations the captured fish are removed by scap net to fresh uncharged water. They recover in from 30 seconds to five minutes, depending upon the size of the fish and the severity of the shock. Less than one per cent of the fish handled are killed. Only when a fish remains too long in the charged field, or comes to rest unobserved against an electrode is it "burned" mortally.

Current Flows Through Water

The present electrical hookup in use on the two Michigan "shockers" is the result of considerable experimentation on the part of Basil V. Hughes, resident manager of the state's Rifle River (Grousehaven) Area in Ogemaw county. The circuit diagram is shown in an accompanying figure. As will be noted from the drawing, electrical current passes through a 2½-ampere fuse or circuit breaker which protects the generator from an overload. From this point it is passed through an ammeter, if desired, thence through a choke coil and fixed condenser to one electrode. When both electrodes are in the water, electrical current flows through the water to the other electrode and back to the generator to complete the circuit.

Modifications of electrodes have been numerous. Hager (1934)[4], the German experimenter, used 10-inch square copper plates on wooden handles to introduce the

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[4]Hager, Franz. 1934. Die Electrizitat im Dienste der Wildbachfischerei. Osterreich Fischereiwirtschaft, Nr. 7/8, Juli-August, 1934, S. 1-5.

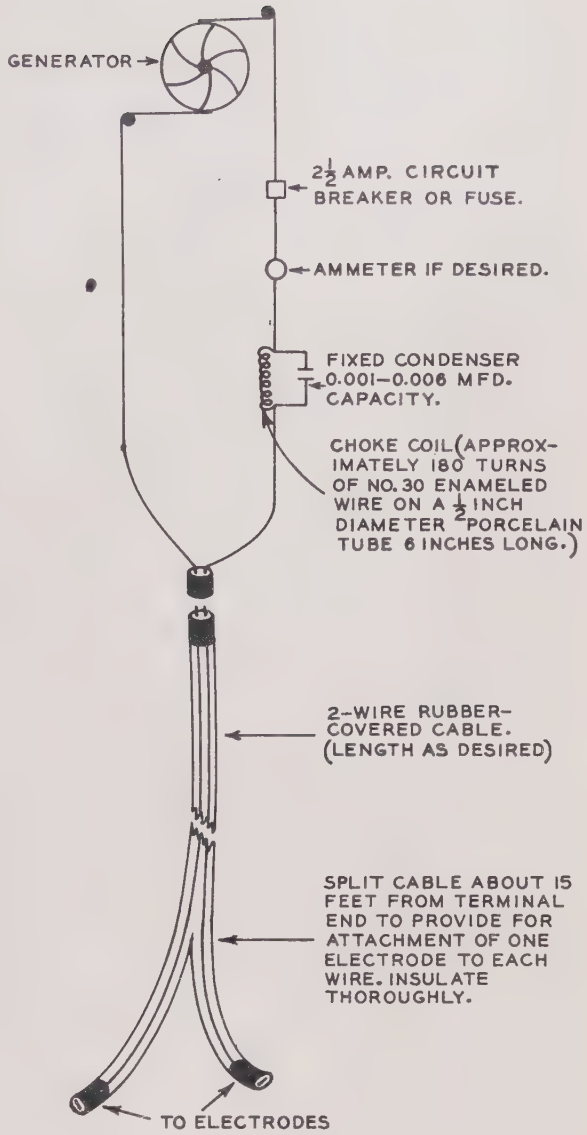
Three-man team operating the electrodes of the "shocker" and picking up the stunned fish with scap nets

Installing a net "fence" to keep fish within a stream section to be censused with the aid of the "shocker"

current to the water. The New York State operators drove a single steel stake or series of stakes into the stream bottom for one electrode, and floated a metal screen connected to the opposite pole of the generator for the other electrode. They noticed that this reduced the voltage available in the water for shocking fish in too many types of stream bottom soils, and instead of stakes driven in the bottom substituted a bare copper wire. However, trials in Michigan with the latter electrode setup proved unwieldy in snaggy streams, and the floating screen created a riffle which made for poor visibility of the fish shocked.

Its Development in Michigan

Our next electrodes were made from ½-inch mesh hardware cloth soldered to a foot-shaped frame of ½-inch reinforcing steel, and were about 16 inches long and six inches high at the heel. While these gave satisfactory results, they could not be operated much farther apart than eight feet, and seemed to "burn" a number of the larger fish. Noting this difficulty, Mr. Hughes built and wired the type shown in an accompanying photograph, which is in reality a widely spaced induction coil of bare wire on a wooden frame 14 x 6 x 1 inches. About 55 feet of copper or phosphor-bronze wire (#14, 16 or 18) are used. With the modified electrode it was possible to shock all sizes of fish passing between the electrodes when they were as much as 12 to 15 feet apart and in water up to 2½ feet deep. More recently Mr. Hughes made up triangular-shaped electrodes on which the wiring of the induction coils is wound in a plane parallel to the stream bottom rather than vertical to it. This carried approximately 95 feet of wire on a triangular frame which is approximately two feet high with a 22-inch base. The wire is spaced at 3/8-inch intervals. This model has worked the best of any yet tried in water up to 2½ feet deep. However, in water deeper than this, the triangular model tends to cause the generator to overwork and heat up. Also, it does not give a large enough charged field, thus allowing many fish to escape, either on the bottom or near the surface. To offset this, a long narrow


GENERATOR
2½ AMP. CIRCUIT BREAKER OR FUSE.
AMMETER IF DESIRED.
FIXED CONDENSER 0.001–0.006 MFD. CAPACITY.
CHOKE COIL (APPROXIMATELY 180 TURNS OF NO. 30 ENAMELED WIRE ON A ½ INCH DIAMETER PORCELAIN TUBE 6 INCHES LONG.)
2-WIRE RUBBER-COVERED CABLE. (LENGTH AS DESIRED)
SPLIT CABLE ABOUT 15 FEET FROM TERMINAL END TO PROVIDE FOR ATTACHMENT OF ONE ELECTRODE TO EACH WIRE. INSULATE THOROUGHLY.
TO ELECTRODES

type of electrode has been built (36 x 6 x 1 inch) and wired with approximately 55 feet of wire spaced 1½ inches apart. Recent trials with this deep-water electrode indicate that it will shock more of the fish from pools four to six feet deep than were reached by the older types of electrodes. With this latest type of electrode the charged field seems to be narrower but deeper.

How "Shocker" is Operated

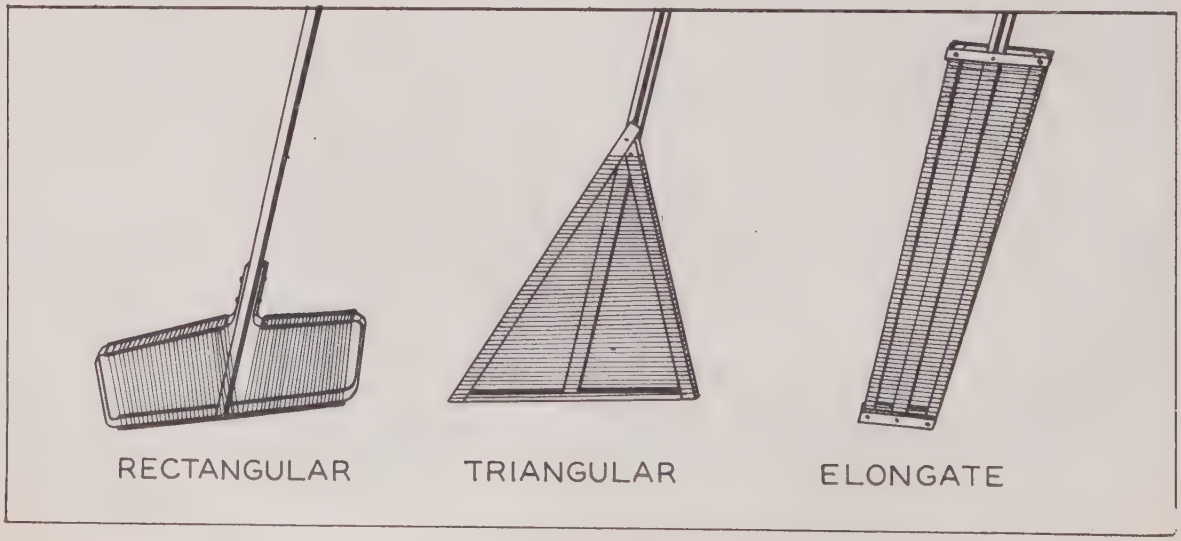
In actual stream-side use, the motor is started with no load on the generator, and

after a short warm-up period the electrodes are plugged in and submerged. The customary procedure is to work upstream against the current. In this manner, the crew is not roiling the water to be shocked, and the stunned fish are carried to them by the water current. Although the equipment can be operated by two individuals, the ideal crew size for intensive work is six men. In population study operations each electrode is handled by one man. The electrode carriers wade on the outside of the area to be shocked, and usually between and slightly behind them one or two assistants are stationed to net the shocked fish as rapidly as they are seen. A fifth individual carries a pail of fresh water to receive the fish, or pulls the boat floating the "shocker," and keeps the connecting wire free of snags. The sixth member of the party tallies the fish handled and records measurements, tag numbers or missing fins of marked fish recovered, or any other data required.

In conducting population studies in a section of a stream, two complete trips are made. On the first trip, all fish captured are given a distinctive mark before they are released, such as clipping a small piece from the tail fin (which can be recognized easily for a short time). Careful record of the number of fish caught and so marked is kept. Two or three days later the shocking crew will go over the same water, and a record is made of the number of marked and unmarked trout captured on the second trip. From these records on the number of marked fish in the stream and the number of marked and unmarked fish taken in the second check, the total population of the stream can be computed. A simple example will illustrate the procedure: On a certain day we shock one mile of stream and mark 100 legal brook trout. Two days later we go over the same water with the "shocker" and capture 75 marked legal brook trout and 27 unmarked legal brook trout. As the entire stream area is covered each time in a random manner, our recovery of unmarked brook trout should be at the same rate as it is for the marked trout. The number (X) of unmarked brook trout present in the stream can be found by solving the simple proportion: 75/100 equals 27/X, in which X = 36. In other words since three-fourths of the marked fish were recovered on the second run, the number of unmarked trout taken in that run (27) represents three-fourths of the total number of unmarked fish present in the stream. The total population of legal brook trout in our theoretical mile of stream is therefore the sum of the marked fish (100) plus the estimated number of unmarked fish (36) or 136 legal brook trout.

How Studies Can Improve Fishing

By conducting population studies on portions of trout streams where intensive creel census data also are available, it is hoped to learn how many legal fish must be present per acre or per mile of stream to furnish sport of decent quality for Michigan anglers. Eventually such data will make possible more accurate and economical dispersion of hatchery-reared fish where they are needed.



The "shocker" is a time-saving device where stream collections of fish must be made, particularly in brushy, snag-filled water where a seine cannot be handled. It will probably be used frequently in the future by stream survey parties, in place of long seines.

Several investigators have found that fish collections for various studies can be obtained with a minimum of time and effort. In the past, almost all the wild brook trout used in the organoleptic tests described by Baeder, Tack and Hazzard[5] were collected with the "shocker."

The "shocker" is useful also to hatchery personnel. For the past 18 months, the waste ditches of the Oden Hatchery have been shocked semi-annually to remove escaped trout residing in them. Such fish are possible sources of infection and disease for the hatchery stock. Another use of this equipment would be to eliminate unwanted fish from hatchery ponds, or from natural streams, before stocking with fingerling fish.

Little Danger in "Shocker's" Use

Contrary to the reports of the earlier investigators, we have not found any danger connected with the use of the "shocker" as long as reasonable care and precautions are taken. All wiring that is likely to be handled is well insulated, and the crew is advised to wear non-leaking boots or waders. Relatively little discomfort is felt if only one hand is immersed in the water when the power is on, and most of our assistants do not hesitate to plunge one arm in to the elbow to net a fish in deep water. A much more severe "poke" results when two hands are placed in the charged field simultaneously. In Michigan to date, only one individual has been shocked in what might be called a severe manner. His waders had a long open tear which permitted free passage of both the water and the electric current. He had worked for about an hour with this bad leak but had suffered no discomfort until he happened to get both hands in the water at the same time in reaching for a fish in a deep hole. The current was cut off immediately, but the resulting jolt left him breathless for a short time. It is the concensus of opinion of those who have worked with the equipment that no serious injury would be incurred unless someone were to be completely immersed under or close to an electrode when the power is on. With ordinary precautions on the part of those concerned, this situation is not likely to occur.

To sum up briefly, in the "shocker" we have a research tool that is several times more efficient than any previously available for capturing fish alive for stream fish research. Also it appears to have possibilities in certain fields of fish-cultural operations, and could be utilized for controlling rough fish, such as suckers and carp in natural waters. Minor disadvantages are its weight and bulk, and the fact that stunned fish cannot be observed when streams are roiled by rains or floods. Despite these slight disadvantages the "shocker" will play a part of increasing importance in stream researches in the future.

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[5] Baeder, Helen A., Tack, Peter I., and Albert S. Hazzard. Trans. Am. Fish. Soc., Vol. 75. In press.

REVIEW

DES FACTEURS PHYSIOLOGIQUES DETERMINANT LES MIGRATIONS REPRODUCTRICES DES CYCLOSTOMES ET POISSONS POTAMOTOQUES

(Physiological Factors Determining the Reproductive Migrations of Cyclostomes and River-Spawning Fish)

by Maurice Fontaine
Bulletin de l'Institut Oceanographique, No. 848, 8 pp. Monaco, 1943

Theories intended to explain the spawning migrations of fish from salt to fresh water have come and gone. Some have left in passing a real contribution to the subject; others might just as well have remained unstated. Although the question as to the exact factors that control and direct these migrations remains to a large extent unanswered, real progress has been made. In our method of approach, at least, for vague philosophizations, teleological interpretations, and the lumping of our ignorance under the mystic term instinct, we have substituted comprehensive physiological studies and thoroughgoing investigations of the reactions of fish to their environment.

Fontaine's paper is more or less typical of the modern approach to the migration question. His theory--he uses exactly that word--is not advanced as the solution to all problems previously unsolved. On the contrary, he emphasizes that it is not complete or final but was set up as a working hypothesis to serve as a guide in his current researches.

For convenience in discussion, Fontaine divides the migration of river-spawning lampreys and fish into two phases: the movement from open sea to brackish-water inshore areas; and the migration from brackish water upstream to the spawning grounds.

The movement from salt to brackish water is held to result from the derangement, accompanying the development of the gonads, in the mechanism responsible for the maintenance of osmotic balance between the fish and the surrounding water. As this mechanism fails, the lampreys and fish find it increasingly difficult to maintain themselves in a strongly hypertonic medium and are forced to seek out waters of lesser concentration of salts. The physiological basis of the break-down of the mechanism regulating osmotic pressures is held to be an increase in the activity of the thyroid. In support of this view Fontaine cites first, experiments which demonstrated that the administration of thyroid products reduces the ability of fish to accommodate themselves to changes of osmotic pressure, and second, observations indicating that the maturation of the gonads is accompanied by heightened thyroid activity.

The search for waters of more favorable concentration of salts accounts only for the movement of lampreys and fish into brackish water. Another explanation must be sought for their migration into fresh water and upstream to the spawning grounds. Indeed, from the standpoint of osmotic pressures, movement into fresh water can prove extremely harmful for fish whose regulatory apparatus has failed. In all probability, the loss of salts from the body is a major source of the heavy mortality that occurs among the migrants. To illustrate how severe this loss of salt content can be, Fontaine gives figures showing that the NaCl concentration of the blood serum of shad captured on their way upstream was 9.30 grams/litre, whereas for a gravid female taken on the spawning grounds the concentration was but 5.47 grams, and for an emaciated, spent male it was only 1.61 grams.

Neither does Fontaine hold it reasonable to believe that a search for more suitable conditions with respect to any other physical or chemical factor (as, temperature or dissolved oxygen) explains the upstream movement of the spawning-run lampreys and fish. With respect to such factors, the total difference between conditions in the lower reaches of a stream and on the spawning grounds is not large, and in a long and varied stream where migrants may travel hundreds of miles this difference is not distributed in such a progressive fashion as to serve as a dependable guide. In a long stream, for example, a lamprey or fish seeking the higher oxygen concentrations on the distant spawning beds almost certainly would have to pass through stretches in which the amount of dissolved oxygen was lower than in downstream waters. It would not be sensible to hold that the lampreys and fish traversing the regions of negative gradient are encouraged by a "foreknowledge" that still better conditions lie ahead.

To explain the upstream movement of spawning migrants, Fontaine hypothesizes first a great increase in the activity of the endocrine glands, such as thyroid, hypophysis, and gonads. Actually this assumption hardly need be termed a hypothesis, as there is ample evidence for heightened endocrine activity in vertebrates at the period of reproduction. The greater activity of the endocrines creates in the lampreys and fish a condition comparable to the hyperthyroid syndrome in man. They experience an all-possessing restlessness, an overwhelming urge to action--a condition that manifests itself in the development of a tremendously strong positive rheotropism. It is this rheotropic behavior that is responsible for the upstream movement.

A critical discussion of the theory just outlined does not come within the province of this review. It is apparent, however, that Fontaine was well advised when he stated that the theory was not complete or final. Certain aspects of migration that the theory seems not to explain may be mentioned. Among freshwater lampreys and fishes that ascend streams to spawn, for example, a quest for waters of lower salt concentration cannot explain the movement from open water to the mouths of streams. These animals spend their entire life cycle in a hypotonic medium. At first thought, this criticism might seem unfair, since Fontaine's discussion concerned only anadromous marine species. Nevertheless, one of the species that he mentioned most frequently, the sea lamprey (Petromyzon marinus), is adapted in the Great Lakes to a completely fresh-water existence. Here, except for the fact that the lamprey is never in salt water, the life cycle, so far as we know, is the same as in the ocean-dwelling form--adult life in open water, ascent of streams to spawn, movement of young to open water after metamorphosis. Again, may not more than rheotropism be required to explain the homing behavior of salmon or the movement of fish across large lakes in which the flow of water must be extremely feeble?

Fontaine's theory certainly will require expansion and amendment. Nevertheless, it offers stimulating material for thought and should serve well the purpose for which it was drawn up, namely, that of providing a point of departure in his continuing researches.

Ralph Hile
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ABSTRACTS

HADDOCK ON THE PORCUPINE BANK, SEPTEMBER, 1944. C. F. Hickling. Jour. Marine Biol. Assoc. United Kingdom 26 (3): 398-407 (1946).--During the war, the stock of fish had complete immunity from fishing for 4 years. Consequently, by September 1944, the Porcupine Bank carried a stock five times as dense as it had been during the best peacetime year.

FURTHER STUDIES OF DEPTH DISTRIBUTION OF FISH, NORRIS RESERVOIR, TENNESSEE. J. S. Dendy. Jour. Tenn. Acad. Sci. 21 (1): 94-104 (1946).--These studies verified those reported for 1943. Fish were caught in waters that contained too little oxygen to support them for extended periods. Useful predictions of fish distribution in deep reservoirs can be made by making temperature observations and comparing the data with those reported in this paper.

L'UTILISATION DES ALGUES D'EAU DOUCE PAR LES CLADOCERES. Marcel Lefevre. Bull. Biol. France et Belgique 76 (3): 250-276 (1942).--Experiments were made to test nutritive value of some fresh-water algae for Daphnia pulex and D. magus. Twenty species of algae were tested. There seemed to be no relation between nutritive value and systematic group. The smaller and more delicate species were apparently most desirable.

DEPTH DISTRIBUTION OF FISH IN THE LOWER WHEELER RESERVOIR, ALABAMA. Paul Bryan and H. H. Howell. Jour. Tenn. Acad. Sci. 21 (1): 4-9 (1946).--Depth distribution of fish was studied by using the catch in gill nets set at various depths. The upper 5 feet of water generally yielded a higher catch than any other 5-foot stratum. Shad represented three-fourths of the catch. Drum were caught mostly in water deeper than 10 feet.

STUDIES OF THE PROTOZOAN PARASITES OF FRESH-WATER FISHES. H. S. Davis. U. S. Department of the Interior, Fish and Wildlife Service, Fishery Bulletin 41, 29 pp. illus., 1947. For sale by Superintendent of Documents, Washington 25, D. C. Price, 30 cents.

This study has shown that the protozoan parasites of our fresh-water fish are more common than was realized and that they include a wide variety of species. All the major groups of Protozoa are represented, but, aside from the Myxosporidia, the most common forms belong to a few families of flagellates and ciliates. Several new species of flagellates are described. The holotrichous ciliate (Amphileptus) described occurs on the gills of a number of fishes and preys on protozoan parasites such as Trichodina and Chilodon. Considerable attention has been given to the morphology and life history of Trichodina, and some new species are described. A new species of Scyphidia is presented. The discussion of Trichophyra ictaluri offers more information about a previously described suctorian. A new species of Chloromyxum is an ectoparasitic myxosporidian; the new species of Myxosoma spends most of its life in the blood vessels. The new species of Dermocystidium, found on the gills of chinook salmon from the Sacramento, has not been reported previously in this country.

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Grubs in Fishes. Jacob H. Fischthal. Biol. Bull. 32, 8 pp., 4 fig.
(Wisconsin Conservation Department, Madison, Wisconsin.)

How to Tell Fish from Fishermen. Ed Zern. 98 pp., illus. Nov. 1947. $2.50.
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